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NORWEGIAN MARINE INVESTIGATIONS

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BERGENS MUSEUM

REPORT

ON

NORWEGIAN MARINE INVESTIGATIONS

1895—97

BY

DR. JOHAN HJORT, O. NORDGAARD

AND

H. H. GRAN

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JOHN GRIEG
1899

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JOHAN HJORT AND H. H. GRAN

CURRENTS AND PELAGIC LIFE

IN

THE NORTHENR OCEAN

WITH TABLES AND 7 PLATES

PREFACE.

In the accompanying treatise we have endeavoured to give the general results of our observations on the Hydrography and Pelagic Life of the Northern Ocean, obtained, of late years, during our Marine-Biological investigations. More detailed results of our observations in Norwegian waters, and the Herring Fishery carried on therein, we reserve for future publication.

Materials for our treatise have also been obtained through the kind assistance of various public institutions and private individuals, and the help thus afforded us is specially alluded to in our work.

We desire to express our thanks to the Officers of the Royal Norwegian Navy, the Meteorological Institute, the Geographical Surveying Board, the Directors of the Bergen Museum, and to all those Shipowners and Masters of vessels who have accorded us their valuable assistance.

June 1898.

Johan Hjort. H. H. Gran.

I. The Hydrographical Conditions of the Northern Ocean.

The greatest part of the Northern Ocean is a deep-water sea. The 1000 mètre curve, in many places approaches nigh to the Norwegian coast (as for instance at Storeggen off Kristianssund, and at Vesteraalseggen). From these points, and across to Iceland, Jan Mayen and Greenland, the depth exceeds 1000 fathoms. Throughout this deep-water sea, the physical conditions at the bottom are very uniform, and of an Arctic character.

If one follows the 400 mètre curve on the Chart of Depths, Pl. 1 one will find the boundary of the Norwegian "coastal banks". It will be perceived that the sea-bottom beyond them descends almost perpendicularly downwards, so that the banks themselves form a sort of barrier or breastwork to the Norwegian coast. It will furthermore be seen that this barrier extends from off the Sogne Fjord to the shores of Scotland, and that the whole of the North Sea is thus of a depth, and similar physical conditions to the banks.

In order to understand the physical conditions of these banks — our especial subject —, one must, above all, remember, that the latter are quite isolated from the cold polar water of the deeper sea. The water which covers our coastal banks comes from the southward, and is carried on to our shores by the well known Atlantic current — the Gulf Stream — which, in the area comprised within a line from Scotland to Iceland and Finmarken, covers the central portion of the surface of the Northern Ocean, and, down in the deep, spreads itself over the banks, the North Sea, the Skagerak, and up to the Swedish Coast and mouth of the Christiania Fjord.

From Pl. 2, it will be seen that the greatest portion of the surface of the Northern Ocean is occupied in summer by water containing over 35 ‰ of salt.

In like manner the bottom from "Eggen" in to the coast is covered with water, the salinity of which is 35 ‰, of a temperature ranging from 6° to 7° Celsius. Only below "Eggen" will a lower temperature be found, down to — 1° at a depth of 900 métres, where the salinity is also less, as the water is mixed with that from the polar ice. In on the coast the salinity, too, decreases, as will be seen from the plate, and therefore one can lay down 3 deep regions according to the physical conditions: —

1. The Arctic Sea Region at the greatest depth.
2. The warm Atlantic Ocean Region.
3. The Coastal Water Region.

A general view of the layers of water to be met with on, and off our Northern Ocean seaboard, will be best seen from the hydrographic section which was obtained, through the kindness of the Geografiske Opmaaling (Geographical Survey), off Hustadviken, where the declivity towards the great depths, Storeggen, is comparatively near land. The section is given on Pl. 5, Fig. 2.

The same layers of water which are met with, the one below the other along the coast, appear on the surface of the sea when far off the land. The hydrographic profile from the Sogne Fjord to the Arctic Ocean, Pl. 4, Fig. 1, thus shews that the salt Atlantic water fills the entire central portion of the Northern Ocean from the surface downwards to a depth of at least 300 mètres (during this expedition deeper investigations were not instituted). The Arctic water, with its lesser salinity, shoves itself like a cold wedge across the Gulf Stream, and in the Arctic Ocean is met with from the surface to the greatest depths.

The thickness of the coastal water varies greatly with the seasons. In the winter it can form a layer up to 250 mètres in thickness, whilst in summer the Atlantic water may be met with, close in to land, at a depth of 40 to 50 mètres.

On Pl. 5, Figs. 3 and 4, will be found a representation of the annual variations of temperature and salinity off the west coast of Norway.

The method of representation has been devised by Mr. Aksel Steen.

The drawings have been made from investigations already published by Hjort [95]*).

In summer the layers in the surface water have been found to be excessively warm, but containing little salt, whilst the Atlantic water forces its way up from beneath. Subsequently the high temperature descends, so that at a depth of 250 mètres the greatest warmth (8°) is met with in December.

The periodical changes thus vary to a depth of 250 mètres, on the west coast of Norway. Up to the present time no investigations have been carried out during the whole year off the seaboard of the Northern Ocean, but there is good ground for believing that the conditions there are not very different to those on the west coast.

*) [ ]. This form of brackets, with figures inside, indicates the date of literary publications.

Mohn ([87], p. 91) reports observations of temperature from Lödingen, which show that at a depth of 100 fathoms the temperature does not vary throughout the year (6°.4 to 6°.5).

There are thus along the entire Norwegian seaboard of the North Sea and Northern Ocean, 3 deep regions of a very well marked hydrographical character, viz.,

1. The Region of periodical changes, to a depth of 200 to 250 mètres.
2. The Atlantic Region, to a depth of about 500 mètres.
2. The Arctic Region.

Of these regions, it is chiefly the uppermost that is of interest to us, as it is our main purpose to unravel all the conditions which may influence the migration of fishes. And it may well be presumed that the great changes produced by currents, by summer warmth and winter cold, and the variations from year to year of the different factors, may be of the greatest importance to the periodical fisheries.

In order to investigate these conditions, Hjort, in 1895, made 5 sections of the sea off the coast between Stavanger and Lofoten, and through the assistance of the authorities of Bergens Museum, Nordgaard was enabled to go over the same section during the winter of 1896.

The results of these investigations are given on Pls. 6 and 7. The salinity is represented in similar tones to those used by Hjort in his former work [95].

Water, the salinity of which exceeds					
	35 ‰	is denoted by	dark	blue	colouring.
34 to 35	- -	„	- light	„	—
33 - 34	- -	„	- dark	green	—
32 - 33	- -	„	- light	„	—
less than 32	- -	„	- yellow		—

This method of representation was founded by the Swedish hydrographers Pettersson and Ekman [91]. That this is right is shown by the fact that the lines of salinity, in many instances, represent the natural boundaries between layers of different origin and character; each of such layers generally possessing its own characteristic conditions of temperature.

This method of division has been tested during several years investigations in the Skagerak, where Pettersson and Ekman separate and recognise the following layers of water:

Atlantic	Water, Salinity		35 ‰ and upwards.
North Sea	„ —	34 to 35	-
Bank	„ —	32 - 34	-
Baltic	„	less than 32	-

On the Norwegian seaboard of the Northern Ocean, the waters of the Gulf Stream can he discerned from the coastal layers hy the 35 ‰ line of salinity. As will be seen from the tables, there is often a great variation in temperature along this line. But naturally all kinds of changes are to be met with, and in many instances it would, possibly, have been more, or equally correct to fix the boundary, for instance, at 34.8 ‰. But, practically, this would make but little difference, and therefore we deem it preferable to use single lines throughout, in order that the figures may retain their value independent of theories and individual opinions.

We regard it as doubtful whether the coastal water can, in the Northern Ocean, be divided into such naturally confined layers as in the Skagerak, but this must be more accurately investigated. On practical grounds we have retained the curves and the same colouring as for the Skagerak waters, but without intending thereby to indicate the various sources of the coastal waters.

For the sake of brevity, we will in the following few words denote those waters whose saline contents amount from 34 to 35 ‰, as "34 water", and, in like manner, describe the other degrees of salinity.

The sections given on Pls. 6 and 7, confirm the correctness of the results given on Pl. 5, Figs. 3 and 4.

In summer the 35 water rises well up towards the surface, being surmounted by coastal layers of various degrees of salinity. On the Norwegian west coast (Pl. 6, 1 a and 2 a) there still remains a quantity of water of less salinity than 32 ‰, probably of Baltic origin. Further North, coastal water is met with, consisting almost exclusively of 33 and 34 water. The temperature in the coastal layers decreases, evenly, from the surface downwards, but the Atlantic water occasionally exhibits a rise of temperature towards the bottom. The coastal layers are thus in summer of littlo thickness, but their salinity is often somewhat low.

If we examine the winter sections we find the conditions entirely altered. The line representing 35 ‰ salinity has on the shores of the Northern Ocean (Table 6, Figs. 3 b and 4 b, Table 7, Fig. 1 b) retired to over 100 mètres of depth, in parts to more than 200 mètres.

On the shores of the Northern Ocean the 35 water will be found somewhat nearer the surface (Pl. 6, Figs. 1 b and 2 b).

Along the entire coast at that season, there will be found a thick layer of 34 water, and also of 33 water, which partly cover the coastal banks.

The temperature of the 34 water is not much lower than that of the Atlantic water, generally from 5° to 7°, falling seldom to 4°, but, on the other hand, the temperature of the 33 water may he 3°, or less than that.

It is necessary now to discover the origin of these thick layers of water, and there are two theories respecting that, which may be taken into consideration, viz., that they are either formed at the spot by a mixture of river and Atlantic water, or that they are brought by currents from other parts.

The Swedish hydrographers are of opinion that, a combination of layers of water of different specific gravities does not occur, to any great extent, except in shallow seas.

In that case, the 34 water on the Norwegian coast could only originate from places whero a vast quantity of water, of a salinity of 34 to 35 ‰, exists. The Swedish hydrographers therefore assume that the 34 water must proceed from the Arctic Ocean itself, or the north western portion of the Atlantic Ocean. In summer there is not any connection between the Arctic Ocean and the shores of Northern Europa, but Pettersson and Ekman have

framed the hypothesis that, in winter, a current runs southwards from the north-east coast of Iceland to the North Sea, or to the Norwegian coast at Stadt.

This hypothesis is mainly based on the biological conditions, for, in the Skagerak, there will be found amongst the Plankton, numerous northern forms at the very time the 34 water attains its greatest thickness (see AURIVILLIUS [96], CLEVE [97]).

As we shall show in the following remarks, the distribution of the Plankton organisms may be equally well explained by other means, but there are, nevertheless, hydrographical facts which appear to support the hypothesis.

Thus it will be seen from MOHN's Chart of Surface Temperatures in the Northern Ocean, for March and August, that during the winter a wedge of cold water advances from the east coast of Iceland in a south-east direction towards the Faroe islands.

It has subsequently been shown by RYDER [95] that a large portion of the East Greenland Polar current turns eastward, running past the east coast of Iceland, instead of flowing onwards through Denmark Straits.

A bottle thrown into the sea off the coast of Greenland in 72° 58′ N. lat., and 20° 36′ W. long., which was picked up after the lapse of three years at the Faroe islands, likewise supports the assumed existence of such a south-flowing Polar current.

It is a matter of fundamental importance in studying the distribution of organisms, and the migration of fishes on the Norwegian banks, to know whether such a current, flowing directly across the Gulf Stream, exists or not. Consequently the Norwegian investigations of the past few years have been directed towards solving this question.

The above mentioned hydrographical section of the Norwegian coastal waters, made by HJORT and NORDGAARD in 1895—96, did not lead to any decisive result, as the steamers placed at their disposal in the coast towns, were not large enough to proceed to the boundaries of the water layers of the coast. On the other hand, in March and April 1897, HJORT succeeded in obtaining a description of the whole of the Northern Ocean through the courtesy of the masters of sealing and whaling vessels.

Mr. JOHANNES BULL, a shipowner at Tönsberg, allowed deep water investigations to be made during the voyage of the "Antarctic" from Utsire to Iceland in the beginning of March, and also from another of his vessels sailing from Iceland to Finmarken in the beginning of April.

In addition to the above, L. TUFTE, master of the steamer "Westye Egeberg", and ship-master J. O. SIMONSEN, kindly collected surface samples of water, and noted the temperatures when sailing to the fishing grounds off Jan Mayen in 1897, while ship-master FODEN did the same, and at the same period, on his course from the Skagerak, south of the Shetlands and Faroe islands to the south western shores of Iceland. The North Sea was simultaneously examined along the steamship routes from Stavanger to Shields, Christianssand to Shields, and Christianssand to Antwerp.

Plate 3, has been published on the basis of these observations. The lines of temperature are given in red, and the steamship routes in black. The cross lines on them denote stations. Wherever the stations are marked on the chart by a small circle, deep-water investigations have been carried out. See besides the Hydrographical Tables B. III—IV.

Mr. FODEN's track has not been marked down, as his report only reached us after the tables and plates had been sent to the printers.

For the sake of comparison, we have published TORNOES' Summer Chart of the Northern Ocean Expedition, supplemented by the results of the Drache Expedition, and by MOHN's Curves of Temperature for August ([87], pl. XXVII) which are denoted on the chart in red.

In comparing these, it will be seen at once that the water of the Gulf Stream, characterised by a salinity of over 35 ‰, is far less widely distributed during the coldest period of the year than during summer; while the Polar current, which in summer barely reaches the south-western point of Iceland, during the course of the winter increases in thickness in two great wedges which extend to 61° and 63° N. lat.

The results derived from deep-water investigations on the line Utsire—Iceland, will be seen on Pl. 6, Fig. 1. Both wedges go down to a considerable depth; the western one being the narrower, but with the lower temperature of the two. The salinity of the eastern wedge at a depth of 200 mètres is 34.88 ‰, and temperature 5°.4; at a depth of 300 mètres 34.97 (see Tables p. 11. 238), temperature 5°.8. This is thus, probably, Atlantic water which has become somewhat mixed by friction with the surface current. At that period of the year the curve indicates 35 ‰ salinity, or the pervading temperature-curve for 5°.

Now comes the question. Can the eastern wedge at any time of the year traverse the Gulf Stream either in the direction of Stadt, as the Swedish scientists at first presumed, or southward towards the Shetland Islands and on by the north east coast of England, as is deemed probable by PETTERSSON and EKMAN in their last treatise [98]? In the latter instance, the current might continue in the coastal currents of the North Sea, as indicated by FULTON [97], and convey the waters along the shores of the North Sea and on, past the north west coast of Jutland, in to the Skagerak.

PETTERSSON and EKMAN find a support to this assumption in the drift of a bottle which was set afloat by RYDER off the south coast of Iceland, which, after the lapse of a year, was picked up off Heligoland.

Our chart, however, shows that the wedges of the Arctic current are certainly stopped by the Gulf Stream in the month of March.

To the north of Scotland the water is very salt, and the curve of temperature for 7° runs past the Shetland Islands in a north easterly direction towards Stadt.

In MOHN's Chart of Temperatures for the Northern Ocean for March, the 7° curve lies still more northerly than we found it in 1897; and, as will be seen from the following, the spring of 1897 was unusually cold in the Northern Ocean.

The western wedge, which, in 63° N. lat., has a surface temperature of 2°.6, is almost imperceptible in 61° N. lat. On Mr. FODEN's voyage from the Skagerak to Iceland, 3rd to 9th March 1897, the temperature on his almost westerly course from 59° 53′ N. lat., to 63° 8′ N. lat., and 19° 42′ W. long., was 7° and upwards, while the salinity throughout was 35.4 ‰, or more. The

only thing along this track which could be observed as indicating the presence of the western Polar wedge, was a slight decrease of temperature. The 8° curve of temperature, between 17° and 19° West long., runs almost up to the Icelandic coast, but at about 15° W. long., turns to the southward, and is only met with again in 6° 20′ West long., and 60° 20′ N. lat.

The Arctic currents are therefore definitely stopped in the south; and this also appears to be the case in the east. The results derived from the observations made on board the two sealing vessels on their voyage from Utsire to Jan Mayen, shew that, off Stadt, the surface of the Gulf Stream is over three degrees of longitude in breadth. It is narrowest in about 65° N. lat., where a combination of the surface layers from the west and east cannot be regarded as entirely excluded. In any case this might be due to a hitherto unknown eastward-flowing side branch of the Polar current.

We do not, however, regard such a combination as likely, and if such really takes place, it is of no material consequence. On the one hand, namely, great bodies of water are to be met with to the northward, of high salinity, and on, the other hand, the Norwegian coastal layers of a like salinity as the Polar current (34—35 ‰) possess a higher temperature than the Arctic waters.

On the coast of Nordland, the 34 water is of a warmth, throughout, of 5° to 6°, even during winter, whilst the temperature of the Arctic waters declines rapidly as they retire from the Gulf Stream.

As it now may be considered proved that, in March, no branch of the Polar current traverses the Gulf Stream, it is not probable that this can happen at any other season of the year. The observations made by the Danish Meteorological Institution (Rothe, [96, 97]) shew that February and March are the coldest months of the year between the Shetland Islands and Iceland, the Polar current having had time throughout the winter to gain in strength and thickness, whilst the Gulf Stream, probably from the autumn till then, has evenly diminished.

According to the accounts of the Swedish scientists, the Gulf Stream ought to be penetrated in December, but during, that month, a pretty high temperature still prevails in the sea within that area.

What then becomes of the cold bodies of water which move in a SSE direction towards the North Sea?

As we have seen that the Arctic water wedge, west of the Faroe Islands, is undoubtedly absorbed by the warm Atlantic water, it is probable that the eastern branch meets with a similar fate. It must become mixed with the north eastern offshoot of the Gulf Stream by which its (the Gulf Stream's) temperature and salinity is lowered. Thereby it is, indirectly, of great consequence, but the Gulf Stream is, however, so paramount, that the mixed currents are of a well defined Atlantic nature, with a salinity exceeding 35 ‰, and a temperature above 5°. The body of water then moves on, partly in a north easterly direction towards the Norwegian coast, and, partly, to the southward into the North Sea. This will explain the drift of Ryder's bottle from Iceland to Heligoland without its having been necessary for Polar water, with its Arctic conditions to flow across the North Sea.

By this means, too, Arctic organisms may well enter the North Sea and Skagerak, conveyed by the Atlantic water which at that time of the year is of a temperature of 5° to 6°. High Arctic animals, such as *Clione limacina* would not be killed by such warmth, as that is not greater than the Summer temperature in many parts of the Polar current (see Pl. 2). It is even probable that the rise of temperature would be favourable, as the Arctic waters are, in winter, exceedingly destitute of organic life.

Neither is it impossible that such sensitive organisms as the Arctic diatoms *(Thalassiothrix, Coscinodiscus)* are, in the combination, transferred to the Atlantic waters, but this supposition is not necessary as they are nevertheless met with in small members in most oceanic layers, as will be more clearly shown in our next chapter.

The hydrographic results hitherto attained, give thus, in our opinion, no ground for assuming that the Polar current at any period of the year traverses the Gulf Stream itself, even by means of a thin superficial layer.

Pettersson and Ekman also acknowledge ([97], p. 30) that "In any case, the hydrographical grounds for this assumption cannot be decisive, unless other facts in support of the hypothesis be found in the results of the biological investigations".

The biological conclusions are, however, less tenable than the hydrographical, as we shall subsequently shew. The cold layers of water met with on the coasts of Norway during winter must, therefore, originate in some other manner.

A glance at the Summer Surface Chart of the Northern Ocean Expedition (Pl. 2), and our Winter Chart (Pl. 3) will apparently convince one that the changes in Norwegian coastal waters can only arise from two factors, viz., the Atlantic water on the one part; the continent and atmosphere, the water from rivers, the warmth of the sun in summer and the cold of the winter on the other. Is it, however, possible by the aid of these factors to explain the changes which, as above indicated, are produced by the seasons in the Ocean, and in the distribution of organisms?

If one studies Pl. 7, Fig. 1 a, which represents the conditions of the West Fjord, Lofoten, early in the summer, one will perceive that the salinity then is very great in the surface water of the West Fjord, and that only in towards the fjords (Salten Fjord) are great bodies of water met with of lower salinity. Hjort's investigations during the summer and autumn 1895, shew that the bulk of these numerous fresher layers increased greatly during the summer and autumn; see, for instance the section from Herö in August, Pl. 7, Fig. 6. The chief changes in the distribution of salinity and temperature in deep water, occur during the month of September. We append here two tables of observations on the salinity and temperature at various depths off the Nordland coast, one for July, the other for September.

Depth.	10th July Salinity.	Temperature.	30th September Salinity.	Temperature.
0 mètres	34.22 ‰	11.1°	32.10 ‰	9.45°
10 „	34.22 „	10.42°	32.45 „	9.6°
20 „	34.55 „	7.75°	32.69 „	9.8°
30 „	34.87 „	6.°	32.75 „	9.5°
40 „	34.94 „	5.05°	33.81 „	
60 „	35.03 „	4.52°	33.94 „	10.°
80 „	35.03 „	4.6°	33.94 „	10.°
120 „	35.19 „	4.9°	34.53 „	7.8°
200 „	35.38 „	5.3°		

In comparing these two tables it will be seen that

1. The 35 curve which, in July, was 50 m. below the surface must be sought for in September at depths exceeding 120 m., the 34.5 ‰ curve was, in July, at a depth of 20 m., but in September was found at a depth of 120 m.
2. The Surface Salinity decreased from 34.2 to 32.1 ‰.
3. The Surface Temperature sank from 11° in July, to 9½° in September, but, as a set off, the temperature down in the deep rose considerably; for instance from 4.6° at a depth of 80 m., to 10°.

These conditions remind one greatly of those which have been shewn to exist on Pl. 5, Figs. 3 and 4, in respect to the west coast. The conditions on the banks in the North are, however, still more instructive, because it must be presumed that the transplacement of the temperature, downwards, is there not so dependent on currents as on the west coast where the Baltic current plays a great part. It was, moreover, very instructive to find that the fresh water played a greater and greater part the further a fjord was entered.

It thus shews that in the North, simultaneously with the increased thickness of the fresh layers, a period of heavy rain sets in. As the accompanying tables shew, the rainfall increases greatly in September, and from that month, throughout the entire autumn until January or February, a lengthy season of rain occurs. It is an interesting fact that, just at that time, the fresh layers increase in thickness, and that it is in the fjords, where the rainfall through the agency of the rivers is most perceptible, that the layers chiefly increase. One factor, which also must be regarded as of great weight in respect to these conditions, is the influence of the winds.

If, in accordance with the annual reports of the Meteorological Institute, one draws curves representing the frequency of the various winds during the various months of the year, it will be seen (as is also shewn in Capt. Rung's atlas of the barometrical pressure over the Northern Ocean) that, during summer, westerly winds are the most prevalent along the whole of the north west coast of Norway. These must, during the summer, contribute to force the Atlantic waters in towards the land. On the other hand, during the autumn and winter the direction of the wind is, to quite a paramount extent, south easterly, interrupted, however, occasionally, by westerly gales. The south easterly winds thus drive the water out of the fjords to the banks, and the gales must, on the whole, mix up the bodies of water, and that to a great depth.

That such a mixture must take place to a very great extent is clear, it appears to us, from the salinity becoming steadily less as the autumn advances. The homogeneousness is greatest in January and February, as both the atmosphere and the fresh water from the rivers cool, especially, the upper layers.

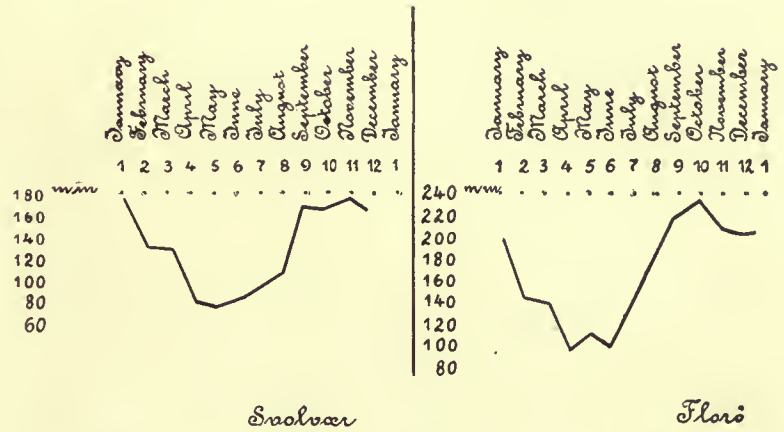

Fig. 1. Rainfall in millimètres, during the various months of the year, at Svolvær and Florö.

It is known that layers of water of different specific gravities are not at all inclined to combine. Thus the Baltic current, during the summer, floats upon the salter layers beneath, without its being possible to observe any admixture.

These conditions do not, at all events, exist in the North during the autumn, or in western Norway. This is seen, for instance, when the density of the water during the winter at various depths is calculated. The density of the Ocean water during the various months of the year may be calculated from Figs. 5 and 6.

If one takes an example from February, one obtains the following figures: —

0	mètres	1.02666
10	„	2666
20	„	2664
30	„	2670
40	„	2679
50	„	2681
60	„	2679
70	„	2678
80	„	2670
90	„	2681
100	„	2686
110	„	2682
120	„	2683
130	„	2689
140	„	2689
150	„	2688
160	„	2688
170	„	2689
180	„	2691
190	„	2696
200	„	2697
210	„	2700
220	„	2705
230	„	2710
240	„	2715
250	„	1.02720

If it be remembered that the limit for the accuracy of the method of investigation may be set at 1 in the fourth decimal, it will be seen that there has been an almost homogeneous layer, in respect to density, from the surface to the bottom. Under such circumstances the power of the wind, as well as that of cold above, must play a great part. Cooling from above would naturally upset the balance, as the upper particles would become heavier and consequently sink down through the lower and light layers. According to Mohn, the cooling of sea water from 6° to 5° would thus increase the specific gravity by 1.2, from 6° to 4° by 2.3, and from 6° to 3° by 3.3 in the fourth decimal. A cooling of the surface layers by 3° would thus, from the above example, cause them to sink to a depth of 200 m.

Even the distribution of temperature shews, moreover, that a vertical circulation must take place. Warmth spreads very slowly through water when its diffusion is not encouraged by circulating currents. The vertical circulation may be checked when the salinity at the surface is much less than at the bottom, this causing a great difference in its specific gravity. Thus, in the upper part of the Christiania Fjord, in September 1897, the temperature, at a depth of 60 mètres, was but 6°, whilst the surface temperature was 13 to 14°. On the west coast where the continental warmth is less, the temperature at a similar depth was, in September, about 12° (see Pl. 5, Fig. 3). There the vertical circulation must, therefore, have been very considerable, much greater indeed than in the Christiania Fjord.

Murray [88] reports some interesting examples of the power of the wind. A Scotch freshwater loch was examined before and after a gale. Whilst the isotherms prior to the storm were all parallel with the surface (a proof of the quiet state of the lake) it was observed, shortly after the gale, that a great portion of the warm water had been blown to one end of the lake.

As will be seen from the following outline, all the isotherms after the gale run towards the bottom in the direction the wind.

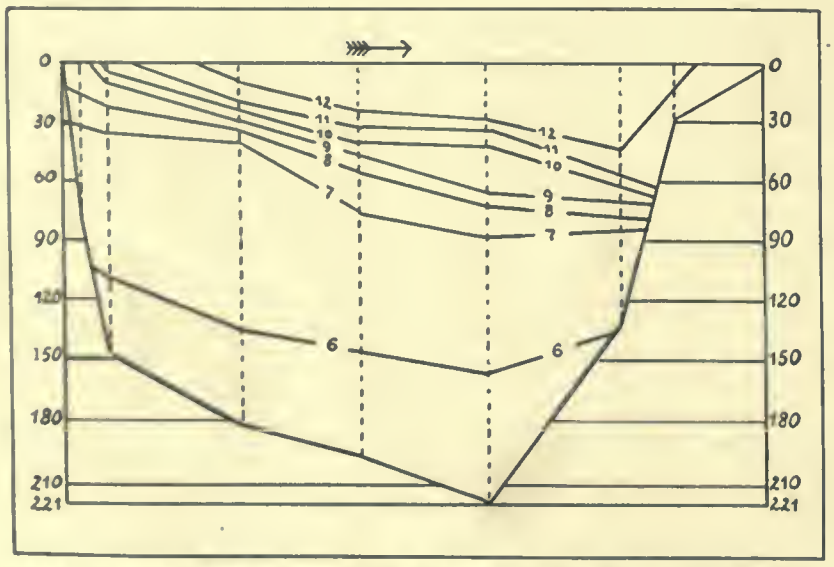

Fig. 2. Section of a Scotch lake after a gale, in the direction indicated by the arrow. From a copy of Murray's Treatise in the Scotch Geographical Magazine 1888 by von Rohr.

Murray has also shewn, from other observations, that gales can even force the warm water beneath the cold, and in such a case a mixture takes place. The Norwegian coastal waters are, during winter, just as homogenious in regard to specific gravity as those of a lake where, in summer, various degrees of temperature are met with at various depths; and when it is remembered that the sea will break off the west coast of Norway in 20 fathoms of water, it will be perceived that also there a great mixture must take place.

If, however, it proves to be the case that the formation of the various layers of water takes place in the manner previously indicated from mere local causes, great fluctuations can, nevertheless, according to one opinion, take place in the bodies of water. The Scandinavian coastal waters, from the Scaw to Finmarken, must be regarded as one hydrographical system which certainly is, mainly, in motion northwards along the shores of Norway, but which by the force of wind may be turned in various directions. It is especially interesting to know from the Swedish investigations, that great changes can take place in the Swedish fjords, as at one moment a fjord may be filled with fresh Baltic Water, while at another the salter water, the so called "Bank Water", of a salinity of 32 to 30 ‰, can force its way in. It thus proves, what the Swedish Scientists have indicated, that where great differences exist in the specific gravity of the layers, they remain like two very different seas who do not associate the one with the other. The summer conditions are very instructive. In the Christiania Fjord, for instance, the cold water of the previous winter will be found along the bottom, while the warm fresher layers appear on the surface.

Even if the amalgamations thus play a great part, it is, however, seen that they do not occur rapidly, and that layers, once formed, can often exist for long periods of the year, without being much affected by the influence of the super-jacent waters. In the course of a long time, months for instance, the great differences may, successively, be overcome, and two layers become amalgamated to one.

We have thus come to the conviction that the changes in the Norwegian coastal waters are dependent, mainly, on the Gulf Stream on the one hand, and, on the other, on local causes. The Polar current has no direct influence; but our investigations prove that it is of a thickness, which, indirectly, must have the greatest influence on the entire current-system of the North Atlantic, and the climate of Northern Europe. And its importance is still further increased through the periodical variations in its thickness and distribution.

Whilst the Polar current withdraws during the Summer to the north eastern coast of Iceland, and the Gulf Stream fills the whole of the central portion of the Northern Ocean, the Polar current increases in thickness during the winter, the Gulf Stream retires, and its waters become partly blended with water from the coast.

Nansen likewise reports [97] that, during the winter, the flow of the surface waters of the Arctic Ocean was in the direction of the Northern Ocean and the Atlantic, whilst the currents during the Summer are varying, in part, the reverse of those of the winter.

Still more interesting than the annual periodical fluctuations of the Polar current, is the fact that, from our observations, it varies in its development in different years.

On Pl. 4, will be seen two hydrographical sections made in the middle of May 1896 and 1897, on board the cruiser "Heimdal". Both were made on the same line from about 61° N. lat., 4° E. long., to 67° N. lat., 8° W. long. The difference between the two is perceptible. In 1896, the Gulf Stream was twice as broad on the surface as in 1897, and, in the deep, it is met with on great areas beneath the shallow Polar current at a depth of 100 to 150 mètres. In 1897, on the other hand, the Polar current is at least 200 mètres in depth, down as far as 64° N. lat., on the meridian of Greenwich. Tbe consequence of this was, that tbe temperature throughout, was 2° lower in 1897 than in 1896.

Comparisons shew that the condititions can vary greatly at like seasons in different years. The cause of this may be due to the derangement of the seasons, or also to the Gulf Stream and Polar current not having a like development in different years.

Several points favour the latter hypothesis. If one lays down the track of the "Heimdal" in May 1897, on the chart for March of that year, it will be seen that the boundary of the Polar current on that line is pretty well unchanged between March and May. On the other hand, it may happen in certain years that the surface temperature in March, can be so distributed that the Heimdal line could be marked down to represent it.

Professor Mohn has been so kind as to allow us to make use of the original observations from which he constructed his Chart of Temperature for March. It appears that in some years, for instance 1867, that the 5° curve of temperature, which may be looked upon as the boundary of the Atlantic water, makes a great turn towards the northwest, in tbe direction of Jan Mayen, up to 63° N. lat., 5° W. long., and that the 8° curve can pass many miles to the north east of the Shetlands (for instance in 1867, 1883).

It thus appears as if the Polar current were differently developed in different winters, and in 1897, it seems to have been of an unusually great thickness. This is also confirmed by comparing the curves of temperature on Pl. 3, with Mohn's Chart of Temperature for March [87, pl. XXVIII], which was constructed on the average temperature from the observations of 19 years (1867—85).

In the southern portion of the Northern Ocean the curves (especially those for 3°, 4° and 5°), in 1897, are furtber towards the south and east than in average years, but as a counterbalance to this, unusually high temperatures will be found along the south coast of Iceland.

The ice-conditions too, can, according to Ryder's investigations vary greatly from one year to the otber*).

As will be seen from the Danish Ice Charts, the boundary of the ice remains somewhat unchanged throughout the months of March, April and May. Ryder likewise states [96, p. 24] "Tbe boundary of the ice, under the influence of prevailing winds may change, somewhat, backwards and forwards, but, in the main, retains its position until the end of May. On the other hand, in June, the boundary of the ice commences to retire in a westerly direction with a growing speed, which increases very considerably in July and August."

We have above shewn that also the distribution of the layers probably remains somewhat unaltered from March to May.

If now a comparison is made between the spread of the ice, and the conditions of the current in the spring of tbe two years 1896 and 1897, it will be seen that there was more ice to the north and east of Iceland in 1896 than in 1897, which was an unusually open (ice-free) year. In 1883, when the conditions of the current were somewhat similar to those of 1896, there was likewise much ice.

From the results already obtained, it thus appears that the Polar current, east of Iceland, is strongest in those years when there is least ice in those parts. But it must be left to future investigations to discover the regular connection between those phenomena.

In their latest report [98], Pettersson and Ekman give an account of some observations on the distribution of tbe Gulf Stream, between Spitzbergen and Norway, during the summers of 1896 and 1897. They have discovered that the Gulf Stream, in those parts, was unusually thick in 1897; while in 1896 it did not extend so far, but, nevertheless, still further than noted in the observations of the Northern Ocean Expedition during 1876—78.

Whilst thus, in 1897, the Atlantic water, between Iceland and Norway, had withdrawn unusually far back until the first half of May, in the latter days of the same month it was of unusual thickness between Norway and Spitzbergen.

These facts are, however, still too isolated to allow of our coming to any definite conclusions from them. The conditions are complicated, and systematic investigations must be made at all seasons, for many years, if any complete knowledge of the system of currents is to be gained.

The observations that have already been carried out but shew the bydrograpbical variations in the Northern Ocean to be so great, that they may be presumed to have an important influence on the changes which both the migration of the fishes, and the meteorological conditions prove to exist from one year to anotber. The connection between the bydrographical conditions and the meteorological, has already been indicated by O. Pettersson [96], and still further reported on by Meinhardus [98].

By means of the International co-operation now being carried on, the question will undoubtedly be solved, though craving much labour, and it can bardly be expected that any great results will be arrived at until the investigators have a sea-going steamer at their disposal throughout the entire year. Up to the present they have been dependent on the goodwill of private individuals, and observations in the open sea have only been carried out, when opportunity offered, during tbose seasons of the year in which the sealing vessels sail to the Arctic Ocean.

*) Ryder [96]. See also the Reports of the Danish Meteorological Institute on the Ice-conditions in the waters east of Greenland, and in Davis Straits [1893—97].

II. Plankton Studies.

Purely hydrographical studies of temperature, salinity, the flow of currents &c. &c. cannot of themselves give such an insight into the system of ocean currents and climate, as can be gained by simultaneously investigating the development and distribution of organisms, and endeavouring to find out the connection between the hydrographical and biological relations.

It has already been shown, from numerous observations, that the hydrographical conditions are of the greatest importance on Marine Organisms. This is best known in respect to those of the bottom; and Petersen's work in the Cattegat [85], and Lorenz's detailed monograph on the Bay of Quarnero [63], have contributed important additions to the enlightenment of the bottom organisms' dependence on the hydrographical conditions.

The study of the Plankton Organisms, has only been taken up of late years; and it is mainly the Swedish biologists Cleve and Aurivillius, who together with the hydrographers Pettersson and Ekman, have sought for the connection between the periods of the Plankton's appearance, and the hydrographical variations.

The above named scientists are of the opinion that the various ocean territories are characterised by special organisms which accompany the waters in their flow. Therefore, they assume that, the origin of a current can be determined by investigating its Plankton.

In order to determine the value of such a conclusion, one must be fully conversant with the distribution and conditions of life of such organisms, and, therefore, before we enter more minutely into the results arrived at by the Swedish scientists, we will give a review of the biology of the Plankton Organisms, and especially that of the Pelagic Diatoms.

Like as is done by Häckel [90], we divide the Plankton Organisms into Oceanic and Neritic groups. The Oceanic forms inhabit the open sea, are entirely independent of the bottom, and can go on propagating in their floating condition without undergoing any regular phase of development. They can be driven in to the coast by ocean currents, and many can continue to propagate there provided the conditions are favourable, in such a case becoming mixed with the Neritic forms.

The Neritic Plankton Organisms are in some manner or other dependent on the bottom; and this, in respect to the various species, can be conditional on very diverse causes. Thus there will be found in the Neritic Plankton a quantity of larva forms of animals, which in a matured state belong to the fauna of the bottom and the coasts (for instance fish, echinoderms, annelids). Some others, such as the medusæ, undergo established phases of youth, whilst the matured individuals belong to the Plankton.

Other Neritic Organisms can certainly live and increase unhindered in a floating state, but experience teaches us that they, nevertheless, keep exclusively to the shallow waters of the coast. They must, therefore, for some reason or other, be dependent on the bottom, and its influence on the waters. This especially affects the lower organisms of the Plankton, the Pelagic Algæ, which constitute the primitive nourishment to be met with in the ocean, and most of these are to be found mainly along the coast.

In the North Atlantic, the Vegetable Plankton consists almost entirely of Diatoms and Peridins.

Both these groups of plants consist of one-celled organisms, which, occasionally, may be united in a chain-like colony, in which, however, each link possesses entire independence.

Propagation occurs by a parting, or dividing of the floating individuals, and continues excessively rapidly so long as the outer conditions of life are favourable to the species concerned.

But, under certain circumstances, which as yet are but little known in respect to the individual species, the partition of the cells ceases, and in the Neritic forms thick walled Cysts or Resting Spores are formed which fall to the bottom.

The Cysts are best known from the Pelagic Diatoms, which we therefore describe at greater length.

The Cells of the Pelagic Diatoms are for the most part very thin walled, the protoplasm forming a thin sack within the walls, whilst the greater portion of the interior of the cell consists of a large sap vacuole. On account of this construction the capacity of the cell is very great in comparison to its solid substance, while the specific gravity is relatively little, but little greater than that of the sea water.

In consequence of this the alga sinks but very slowly to the bottom, even if it does not by its own powers, viz., by the formation of gas, keep afloat. Moreover, the surface is often covered with hollow hairy growths (as in *Chætoceros)*, or fine slimy

threads proceed from hollow spines (as in *Thalassiosira**), which contribute to the alga's powers of flotation.

At the same time that these peculiarities in the construction of the alga are favourable to it, in its floating state, so long as the conditions of life are propitious, they weaken its powers of resistance to variations in the physical and chemical condition of the ocean. In the open sea the changes are slight, and take place gradually; but, near the coast, much fresh water combines with the sea water, and the temperature varies much more there with the seasons than in the open sea in corresponding latitudes.

As a protection against such variations, the Neritic Diatoms are given their spores, which are formed towards the close of the period of vegetation.

The protoplasms of the cells withdraw from the hairs (in *Chætoceros)*, and away from the walls of the cell, first on one side, where a new, thicker, arched valve forms inside the old one, thus dividing the original cell into two spaces, of which only one contains the protoplasm. Subsequently, the protoplasm withdraws from the other side of the original cell, and becomes enshrouded in a thick, strong silicious shell. The spore is than fully formed, but remains enclosed within the walls of the original cell until that falls off or dissolves. The substance of the cell has now become reduced to half or quarter of its former capacity, and the walls are about three times as thick as the vegetal cell walls. The walls may often be furnished with spines or other appendages, but these spines are solid, not hollow like the hairs of the vegetal cells.

In the different families and species, the method of formation of the spores varies somewhat in the details, but in most of them it takes place in the manner above described, and has already been accurately defined by Schütt [88] in respect to some Neritic *Chætoceros* species from the Bay of Kiel.

As soon as a species commences to form spores it gradually disappears from the Plankton, the spores sinking to the bottom as indicated by Schütt [88]. They possess a much greater power of resistance than the vegetal cells, as the diffusion takes place less rapidly through the thick cell walls. Thus, for instance, they are much more slowly discoloured by alcohol than the vegetal cells.

The spores have been known from the earliest period of diatomic research. The diatoms have been mostly sought for in samples from the bottom, in which the vegetal cell-walls of the Pelagic forms are very seldom met with, whilst the spores are found somewhat frequently.

Owing to this it is that Ehrenberg [45] has figured several forms of spores, without however knowing their true character. The first species of the *Chætoceros* was but described from the spores, whilst the accompanying vegetal cells were only discovered many years afterwards *(Chætoceros didymum, Ch. furcellatum).*

Spores within the vegetal cells, the so-called inner cells, were first described by Brightwell [56] in the *Chætoceros Wighami*, subsequently by Lauder [64] in some species of *Chætoceros* obtained from Hong Kong, and in the *Bacteriastrum varians* later by Castracane [79], Grunow [84], and by others. It was first Schütt who subjected them to a detailed investigation.

By the efforts of Cleve [94, 96, 1—2, 97] and Gran [97, 1—2] spores have been shown to exist in most of the Neritic Diatoms found on our shores, and these are also being discovered in species in which they were formerly unknown. We therefore consider it likely that in the course of time they will be found in all Neritic forms.

Up to the present they are known to exist in the following 28 species of the Norwegian coasts.

Bacteriastrum varians
Biddulphia aurita
— *mobiliensis*
Chætoceros cinctum
— *constrictum*
— *contortum*
— *coronatum*
— *curvisetum*
— *debile*
— *diadema*
— *didymum*
— *furcellatum*
— *gracile*
— *laciniosum*
— *radians*
— *Schuettii*
— *scolopendra**)
— *seiracanthum*
— *simile*
— *sociale*
— *teres*
— *Weissflogii*
— *Wighami*
Fragilaria oceanica
*Melosira hyperborea**)
Rhizosolenia setigera
Thalassiosira gravida
— *hyalina*
— *Nordenskiöldii*

The Norwegian Neritic Diatoms in which the spores are not yet known, consist of the following only, apart from the true rarities:

Cerataulina Bergonii
Chætoceros crinitum
— *Willei*
Coscinodiscus polychordus
Ditylum Brightwelli
Eucampia Zoodiacus
Guinardia flaccida
Lauderia annulata
Leptocylindrus danicus
Podosira glacialis
Skeletonema costatum
Thalassiosira gelatinosa
(= Coscinodiscus exentricus v. gelatinosa).

Most of these are rare species, we having met with but three in any great number *(Guinardia flaccida, Leptocylindrus danicus, Skeletonema costatum).* It may, however, occasionally be difficult to determine whether a species is oceanic or neritic, especially if

*) A detailed account of the organic structure and various floating appliances of the Plankton Diatoms is given by Schütt [93].

*) According to new, and still unpublished observations by Gran.

it only rarely appears, and then in small numbers. It is, therefore, not improbable that some of the latter species which have been denoted above, will. on further investigations being made, prove to be oceanic (for instance *Guinardia).*

The spores are also known to exist in a number of fresh water forms. In the Plankton Diatoms of lakes, they have only been known of later years (Lauterborn [96]. B. Schröder [97]), as these algæ themselves were only discovered a few years ago. But in bottom-forms. and especially in those species which inhabit ponds and pools, they have long been known and spoken of under various names such as, inner cells, gemmæ "Craticular-Zustände"; see Pfitzer [71]. Other freshwater algæ have also similar cysts as the diatoms.

In the freshwater forms they appear, especially when the ponds dry up. The algæ, by their aid, repose in the dry mud until they again obtain favourable conditions for their development. This power of resting, which is a necessary condition for populating the pools with life, is also met with in animals of various kinds; crustaceæ, rotatories, and other dwellers of the ponds can, like the algæ, form encysted resting stadia.

In these organisms the spores chiefly serve the purpose of preventing them from drying up. The outer conditions which lead to the formation of spores in the Marine Plankton are still unknown. Neither does one as yet know anything concerning their sprouting, or the conditions under which such takes place.

The physical and chemical factors which, it may be presumed, are of importance to the life of the algæ, are light, warmth, and the chemical constitution of the sea water. All these factors vary most in the upper layers of water, whilst the conditions as a rule become more uniform the deeper one descends.

If now the spores, as we presume, are of any consequence to the continued existence of the species, then the diatoms must be not only dependent on the hydrographical conditions of the surface layers in which they vegetate, but the hydrographical conditions at the bottom must also be of such a nature that the spores may periodically rest, or be roused into sprouting. If a rich Neritic Flora is to have a chance of developing itself, and be annually renewed from spores at the bottom, the latter must not lie beyond such a depth as to allow of the yearly variations in light, temperature &c. reaching it.

Our deep Norwegian fjords, which are constantly dark at the bottom, and where the bottom-temperature throughout the year can only vary from 1° to 2° degrees, cannot be expected to contain any stationary Neritic Plankton. On the other hand, in shallow fjords or coastal waters, the light can penetrate, and the annual periods of temperature can be perceived, more or less perceptibly, down to the bottom itself. There during summer a rich flora of southern forms can be roused to life, which rest during the winter, whilst, on the other hand, during that season, the northern species can meet with so low a temperature as to allow of their growing up.

From this point of view we will compare the Neritic Flora of the various northern coastal waters, which hitherto has been best known, and endeavour to shew that the true conditions correspond exactly to our assumption of the importance of the bottom.

The typical specimen of a shallow fjord is Lim Fjord, whose remarkable plankton-conditions have been described by Dr. C. G. Joh. Petersen in his lately published work [98].

The depth of the fjord averages 3 to 4 fathoms, and the hydrographical conditions may be regarded as unique from the surface to the bottom.

The temperature may vary from 0.3° to 18°.4 Celsius. According to Petersen's investigations, the Plankton is excessively abundant for most part of the year, and notwithstanding that the water in the Lim Fjord is in constant movement from the North Sea to the Cattegat, it nevertheless possesses a Plankton Flora, which both in quality and quantity is sharply defined from that of the North Sea, and which is, in the main, different from that of the Cattegat.

The Lim Fjord also possesses a local, stationary Diatom-Plankton which changes in composition with the seasons, but which proves to be quite different from the Plankton in the neighbouring seas at all times of the year, as is proved by Petersen who carried out three series of continuous observations throughout the Lim Fjord from the North Sea to the Cattegat (October 96, April and July 97).

The various species succeed each other with the seasons. In December and January, the Plankton is very scarce; in February. and especially in March, the winter forms *(Biddulphia aurita, Lauderia cystifera)* appear; in April these are succeeded by the spring forms, which in that month bring the amount of Plankton to a maximum. In May and June, the Plankton is somewhat less, but during the summer months of July—September the fjord was again filled with great quantities of diatoms, especially *Chætoceros debile.*

All those species which characterise the Lim Fjord Plankton are Neritic forms which produce spores. Petersen concludes that rich Diatomic Plankton must originate in the Limfjord itself from the interaction of the bottom and the waters that flow in to the fjord. Of what this interaction consists he cannot express any decided opinion.

It appears to be his idea that the great development of the Plankton Flora in the Lim Fjord is due to the exceptionally favourable conditions that are present there, as a greater amount of nitrogenous compounds are conveyed to its waters than is to be met with in the open sea, or deep fjords.

This idea, which in connection with other matters, was first promulgated by Hensen, and subsequently by Strodtmann [96], has been adopted in respect to the Plankton in lakes, seems to be well founded, when it is remembered that the open sea is highly deficient in nitrogenous compounds.

In the mud of shallow fjords a great mass of organic substances are always present, which, gradually rotting, give off nitrogen to the water.

This factor, however, only becomes of consequence provided germs are present which can utilise the favourable conditions of nourishment. One may imagine that the diatoms enter the fjord from without, and the oceanic species, which especially in May and June appear in quantities, are probably introduced by the in-flowing curr nts.

But the Plankton of the Lim Fjord chiefly consists of Neritic forms, and as the Neritic Flora of the fjord is different from that

of the surrounding seas, it is most reasonable to assume that the Plankton is really stationary, and that it is renewed by spores from the bottom.

The abundance of the Plankton in the Lim Fjord may, in our opinion, be best explained from there always being in the mud of the bottom spores sufficient, and ready to sprout, as soon as the conditions necessary to their existence are favourable. Similar conditions to those of the Lim Fjord are also to be met with in the Scotch firths which are shallow, and where the water is calm, so that the alluvial mud containing the organic remains can fall to the bottom and settle there at a depth of but a few fathoms. At certain seasons of the year they contain, according to G. Murray [97] enormous quantities of Neritic Diatoms, especially *Skeletonema costatum*.

Nor can it there be determined, without investigation, whether this abundance of Plankton Flora is chiefly due to the amplitude of the annual variations of temperature at the bottom, or the great abundance of nitrogenous compounds. In every case the diatoms make the conditions of nourishmeut still more favourable for the small animals which live in the mud on the bottom.

Also, according to Vanhöffen's investigations in the Karajak Fjord, West Greenland [97], an abundant Diatomic Plankton exists, which entirely disappears on the appearance of frost in October. It is the power they have of forming spores that enables these sensitive organisms to remain in such high northern latitudes, and employ the short summer in producing, comparatively, enormous quantities of organic matter.

The Cattegat's Plankton has been very well investigated by Cleve [85, 96 and especially 97], and Petersen [98]. The depth in the Cattegat is not too great to allow of the annual changes of temperature reaching the bottom, more especially as the currents occasion great variations in the hydrographical conditions (see Pettersson and Ekman [97]). It will thus be seen from, for instance, the report of the Danish Commission (Rördam [96]), that the bottom temperature in the Cattegat on the 26th February 1892, averaged less than 5°; in May about 6°, while on the other hand it was about 11 to 13 degrees in November. The amplitude of the annual variation of temperature at the bottom is thus at least $11 \div 5 = 6^0$; at most parts really much more than this.

Especially in the Northern portion of the Cattegat there exists an abundant Neritic Plankton-Flora. During the spring, in March and April, when the lowest temperatures have reached the bottom, there crop up great quantities of Northern, in part Arctic species (*Thalassiosira Nordenskiöldii, Th. gravida, Chætoc. diadema, sociale*), cfr. Cleve [96], Tab. II.

During the autumn, Southern forms may be met with in quantities (for instance *Chætoceros didymum, Ch. Schüttii*). According to Petersen's investigations [98], there is, as a rule, a great difference between the surface Plankton and that of the bottom. Whilst, in the salter layers at the bottom, there may be a rich flora of various species of *Chætoceros*, and others, the surface layers only possess quantities of *Rhizosolenia alata*, mixed with many dead specimens of the flora from the waters of the bottom.

The species which vegetate in the deep layers thus do not appear capable of living in the less salt water, which on the surface pours out from the Baltic. This is probably the reason why the Plankton Flora of the Cattegat does not consist of so many diverse species as that of the Skagerak.

The Skagerak's Plankton has been still better investigated than that of the Kattegat, and better than that of any other water area of similar extent.

The vegetable Plankton is best known from Cleve's works [94, 96, 97]. This author, especially in his last great work [97], has published a vast amount of information which has been partly gathered at one time from a great area of operations, partly during a lengthy period at established stations.

To this may be added the very important contributions of Petersen [98], besides a great number of samples which we have collected and examined, and whose contents we shall treat of in a subsequent work.

The Neritic Plankton of the Skagerak is very similar to that of the Cattegat, consisting, mainly, of the same species, with a few more, and all these species appear at about the same season of the year. Thus from Cleve's work [97], Table XI, will be seen the Diatomic Planton at Væderö for the entire year 1896. In the latter half of February we meet with a Plankton, which, besides a number of oceanic forms, contains chiefly *Thalassiosira Nordenskiöldii, Th. gravida, Coscinodiscus excentricus v. gelatinosa, Chætoceros teres,* and a little later on *Chætoceros debile, diadema* and *sociale*. These are surplanted, little by little, by *Chætoceros constrictum* and *Leptocylindrus danicus,* which reaches its maximum in April.

In May and June the Neritic forms retire, and are relieved by the Plankton characteristic of the Baltic current *Rhizosolenia (alata var.) gracillima,* and, besides, a majority of *Peridines*. At Væderö the Neritic species, *Chætoceros curvisetum, didymum, Schüttii, Ditylum Brightwellii,* only reappear in September. In the Gullmars Fjord they occur somewhat earlier, in July and August (see l. c. Tab. XII). In the Skagerak the circulation and change of waters is so constant*) that no areas can be fixed as having local characteristics either in hydrographical or biological respects.

It is true that there are some fjords, in which the bottom-water is prevented from circulating throughout a great part of the year, owing to reefs at the entrance; and, of these, Gullmars Fjord in Bohuslän, and Christiania Fjord have been thoroughly investigated. In their upper water-layers both these fjords contain a Plankton which in no important characteristic deviates from that of the Skagerak, being, may be, especially at certain times, somewhat less plentiful. From many observations in the Christiania Fjord, we have derived the impression that the Diatomic Plankton, to a great extent, enters the fjord from without.

The upper water-layers too, circulate constantly with those of the Skagerak, whilst the hydrographical conditions at the bottom are so uniform, that while it certainly can be a home for a characteristic Oceanic bottom-fauna, it cannot sustain any local Neritic

*) See, amongst others, Pettersson and Ekman [97].

Plankton. As already mentioned the bottom temperature throughout the year remains at 5° to 7° degrees.

On account of the circulation in the upper layers of water of the Skagerak and Cattegat, the chief thing to be determined is the extent to which the individual parts of the coast in the two seas contribute to the joint stock of Plankton. Probably all the surrounding shores are centres of development of Neritic forms.

The circulation makes the conditions of life so uniform that, in all probability, those species which are almost alike sink to the bottom with their spores, and from these spring to life again along the entire coast, just as, for instance the fixed algæ-flora is somewhat uniform on all the shores of the Skagerak. The circulation favours also the Neritic forms, as it conveys the warmth of summer and the cold of winter along the coasts down to a considerable depth, so that the range of temperature may be extraordinarily great. Thus, for instance, in October 1897, there were warm layers of water crowded up in the north eastern portion of the Skagerak, of such a depth that the temperature (at Langesund) was 12° down to a depth of 250 mètres.

The Neritic Plankton of the North Sea does not appear to be nearly so plentiful in individual forms as the Skagerak.

This is shewn up chiefly by PETERSEN's investigations [98. Table I]. The North Sea proves to be not only less full of Plankton than the Lim Fjord and Cattegat, but the species met with in it are, paramountly, oceanic. Of Neritic forms, it is really only *Biddulphia mobiliensis*, which occurs in any nameworthy quantity.

CLEVE's Tables for the North Sea [97. Tables VI, VIII, IX] also indicate a majority of oceanic forms. The German Expedition to the North Sea, found lesser quantities of peridins and diatoms than in the Baltic and Gulf Stream [see SCHÜTT, 93], whilst G. MURRAY [97] found great quantities of Neritic diatoms during the spring along the North Sea seaboard of England, especially *Skeletonema costatum*. On the North Sea seaboard of Norway, from Lindesnæs to Stadt, no previous studies had been made. The results of our investigations there will be found in Table 1, station 1—6; Table 3, St. 73—76, and Table 5, St. 179—185. The Stations 1—3 and 179—183 are off Stavanger; 4—6 and 183—185 off Marsten Lighthouse near Bergen, and 73—76 off Bremanger near Stadt.

The Summer Neritic Plankton on the Norwegian littoral of the North Sea is typically represented in the samples obtained by HJORT off Marsten (st. 4) on the 26th June 1895. This Plankton is rich in species, amongst which most of the autumnal forms of the Skagerak are met with. But the relative conditions in respect to numbers are somewhat different, and some species, for instance *Chætoceros Schüttii* are replaced in the North Sea by others, and thus *Chætoceros Willei* and *Ch. cinctum* are characteristic forms of the North Sea littoral.

It will be seen that, in the Tables, we have divided the Neritic Diatoms into Summer, Winter and Arctic forms. The latter are not met with in the Skagerak or on the North Sea littoral, and the Summer and Winter forms are divided chiefly according to the seasons in which they occur in greatest numbers in the Skagerak.

Even in the Skagerak, in which the Summer and Winter Plankton is very different, the boundary between the Summer and the Winter forms is not always easily drawn, and some individuals of true Summer forms (for instance *Chætoceros didymum)* may be met with in the middle of winter, whilst Winter forms may be encountered in small numbers at the warmest period of the autumn. CLEVE's Tables shew, however, that each species attains its maximum at a fixed period of the year. On the West Coast this is not so marked. We thus see that so late as the 26th June, no small numbers of true Winter forms (*Thalassiosira Nordenskiöldii, gravida, Chætoceros diadema)* are to be met with.

In the Bergen Fjord*), almost similar species are to be met with throughout the entire summer, as those contained in the above mentioned samples from Marsten. From Table 3, St. 73—75, it will also be seen that a like plankton, if even somewhat poorer, is to be found all the way up to Bremanger, where, it keeps but close in to the coast, which however agrees with the fact that it consists of Neritic species.

An impression of the Winter Neritic Plankton of the West Coast will be gathered from Table 5, Stations 179—182. The samples of Plankton were collected by NORDGAARD whilst making the hydrographical section off Stavanger (7th—9th February 96), and off Marstenen near Bergen (14th—15th February). On the surface the Plankton was still somewhat sparce, but a little deeper down, especially at the outer stations (181, 184, 185), where the Atlantic water with its greater temperature comes nearer to the surface (40 mètres at Station 184), there was found, amongst the oceanic forms a considerably large number of Neritic species. GRAN found that the same kind of Neritic species were abundantly developed between Lindesnæs and Stadt in March 1898. The species there were the same as those in the Skagerak, the quantative relations only being somewhat different. The Winter forms were not so paramount as in the Skagerak, and there was not so small a number of true Summer species amongst them.

This agrees with the hypothesis that on the West Coast the variation of the temperature between summer and winter is not so great as in the Skagerak, the conditions on the littoral of the North Sea, both in respect to hydrography and biology being more oceanic, whilst in the Skagerak they are more "continental", if we can employ this term in relation to an area of water.

It is possible too, that the bottom of the North Sea does not present so favourable conditions to life as might be imagined. The North Sea, as we may perceive from our charts, is also to a great extent filled with oceanic bodies of water. It is a restless sea in which the boundary of the mud (J. MURRAY's "mud-line") is first met with at a depth of 80 fathoms. The bottom consists for the most part of sand and gravel, bare of all higher alga-vegetation, notwithstanding that the depth is not so great as to preclude its growth if it found a suitable soil. It is possible that the spores fall more easily to the bottom, and are retained in more tranquil parts where the bottom is covered with mud at a depth of a few fathoms. The only Neritic Diatom which appears in plentitude in

*) Samples of Plankton from this fjord have been kindly placed at our disposal by NORDGAARD.

the south eastern parts of the North Sea, is a species with large and heavy spores, *Biddulphia mobiliensis*.

On the West Coast of Norway there are only some places within the belt of islands, which are so shallow as to allow of their favouring the growth of a Neritic Flora. Outside it there exists the Norwegian Channel, and, inside it, deep fjords where the bottom temperature is almost unvaried throughout the year. The fjords, so far as the investigations hitherto made have shown, contain a very poor Plankton.

Finally we come to the seabord of the Northern Ocean which forms a most decided antithesis to the shallow Lim Fjord with its abundant Neritic Plankton. If ones studies the Sea Charts, for instance those of the coast of Nordland, one will find that very few, and then only small shallow parts are to be met with. The numerous islands and rocks rise almost invariably perpendicularly from a depth of 100 fathoms.

At such a depth the temperature is almost unchanged throughout the entire year; thus the observations taken off Lödingen during the years 1879—81 (see Mohn, [87], p. 91) at depths of 100 fathoms give the highest temperature (July 79) at 6°.6, the lowest 6°.3, the annual variation being, therefore, but 0°.3 at the outside. At a depth of 50 fathoms (92 mètres), the variation is 2°.8 (8°.3 in October, 5°.5 in January).

The boundary of the mud is too, off the coast of Nordland, at still greater a depth, viz., 100 fathoms, than in the North Sea.

In our opinion all these conditions must be very unfavourable to the formation of Neritic Plankton.

In reality too, there are excessively few Neritic Diatoms on the littoral of the Northern Ocean, compared with those on other coasts.

During the summer of 1895, Hjort studied the Plankton, along the entire coast, from July to September. The results derived from his observations are to be found in Table 1, Stations 7—41. Moreover the "Hansteen" collected a number of samples in June 1896 (Table 3, Stations 77—85), and the Swedish Expeditions to Spitzbergen in 1896—97, collected Plankton off the Norwegian coast in June and August 1896, and in May and July 1897. The contents of these samples were examined by Cleve, and the results published in Pettersson and Ekman's latest work [98] Tables 1—3, pp. 48—51.

It will be seen from all of these tables that small quantities of Neritic Diatoms are to be met with, during summer, along the Norwegian shores of the Northern Ocean.

No great plentitude of individuals was to be found in any of the samples, and only a few of them contained, mainly, Neritic species to any appreciable extent. One sample obtained off the Trondhjem Fjord in May 1897, contained *inter alia,* mainly *Chætoceros debile*, and another sample obtained off Ranen Fjord on the 23rd May contained *Skeletonema costatum*.

Somewhat richer is a sample from the harbour at Tromsö, obtained on the 12th June 1897, referred to by Cleve in his Phytoplankton [97], p. 8. Its characteristic form is given as *Ch. contortum*, which is a true Neritic species. Several of the species were found by Cleve to possess spores. With almost these few exceptions, the samples are nearly entirely free of Neritic Diatoms, but, on the other hand, some contain great numbers of Peridins and Crustaceæ, and others some Oceanic Diatoms, especially *Rhizosolenia alata, f. gracillima (Rhizosolenia gracillima,* Cl.) which on the West Coast are characteristic of the Baltic current in summer. See our Table 1.

Hjort found that the Peridins and Crustaceæ increased in numbers as autumn were on, as the water became warmed in the neighbourhood of the land. Possibly the Peridins here replace the wanting Diatoms, and in place of them make use of the light and warmth of summer in forming a stock of nutritious elements which benefit the other organisms of the ocean.

It is especially *Ceratium tripos* that occurs in great numbers*), it being a hardy and contented species which is to be found almost every where in the North Atlantic Ocean at all times of the year. It is, therefore, so far Oceanic, being entirely independent of the bottom. On the other hand, it probably requires so high a temperature to promote a great development as that which in high latitudes is only met with along the coast during summer. It may, therefore, with us, with a certain amount of truth, be called Neritic, as it mainly appears on the coast.

The variety *longipes* developes itself under opposite conditions, especially on our coasts, winter and spring, when the coastal water is cooled, and the variety *arctica* is the characteristic form in the Arctic seas.

During the winter, our Northern Ocean shores are still less prolific in Neritic species than during the summer.

Of the numerous samples collected by Nordgaard in February, March and April 1896—97 (Table 5, Stations 186—198. Tables 6 and 8), there are but some few (from Reine in Lofoten, Station 215 and Stations 529—30, 1st April 1897) which contain Neritic species, and these few species only in small numbers. The species which are to be found at that season are Arctic diatoms such as *Chætoceros furcellatum*, *Thalassiosira hyalina*, and *Fragilaria oceanica*, as well as some which also on our west and south east coast appear as winter forms, such as *Thalassiosira Nordenskiöldii, Th. gravida, Chætoceros sociale, debile, diadema.*

All these species are likewise to be met with off the coasts of Greenland (see Gran, 97. 2—3).

In March 1898, Gran found the same species in somewhat greater numbers along the coast of Söndmore and Romsdal up to the month of the Trondhjem Fjord. This characteristic Plankton Flora thus appears to be spread along the whole of our Northern Ocean seabord during March and April, its southern boundary then appearing to be at Stadt.

Neither in the number of species, nor in absolute quantity can it compare with the Plankton Flora which springs up at the same season in the Lim Fjord, the Cattegat, the Skagerak or even on the West Coast, and which gives nourishment to all the Pelagic forms of larva which commence developing in spring.

Greater or lesser numbers of a remarkable Flagellat, *Phaeocystis Poucheti*, (Har.) Lagerh., are almost invariably to be found together with these Arctic neritic forms. Its development is as yet

*) The various varieties of this species (var. *macroceros*, *longipes*, *arctica*, *Bucephalos)* are not separated in most of the Tables.

unknown, and we, therefore, dare not attempt to decide whether it is of Neritic or Oceanic origin. It belongs to cold seas, but, during the winter, may be found down in the North sea, and even in small numbers, in the Christiania Fjord.

A glance at our Tables will shew that these Neritic, Arctic forms are but met with, here and there, in small numbers, otherwise all the samples contain but a non prolific Oceanic Plankton (*Coscinodiscus*-species).

On the whole it will be seen that the quantity of Neritic Plankton decreases in richness from the Lim Fjord to the Cattegat and Skagerak; is still poorer on our North Sea littoral, and off the coast of Nordland dwindles down to a minimum. It cannot be due to the change to high northern latitudes. As we have stated, a very rich flora of Neritic Diatoms is to be met with in Karajak Fjord in North West Greenland. It can, therefore, but be due to the bottom conditions, and agrees with our views, that the Neritic Diatoms demand such conditions of life, that their spores are able to sink to the bottom, be preserved there, and subsequently aroused again for development.

The Oceanic Organisms form a contrast to the Neritic.

The conditions necessary to existence in the open seas are less varying than in by the land. The temperature may rise and fall with the seasons, or as the bodies of water advance; but the variations proceed slowly. Still more slowly do the changes in the salinity of the ocean occur.

The ocean, therefore, also possesses a Plankton much more uniform than that met with on the coasts. So long as it remains in the same current, the composition of the Plankton varies very slightly.

The Pelagic organisms do not require any means of protection against the variations in the temperature and salinity. Each individual species may be adopted for life within very narrow limits of temperature, yet nevertheless find an immense area in which it can develop itself abundantly.

The Pelagic Diatoms which we shall specially treat of, may, like other diatoms, become developed in enormous numbers at certain times. When a rich Diatomic Plankton is met with in the ocean, it will be found to contain, as a rule, one or some few species in overwhelming numbers.

According to SCHÜTT [93]. there live, during summer, in the Irminger Sea, vast numbers of *Thalassiothrix longissima,* and often, in the North Atlantic, *Chætoceros decipiens* or *Ch. boreale* may be met with developed in equally great numbers. Other species may occur amongst these masses, but often in quite an insignificant number.

At other times great stretches of ocean can be almost entirely free of Diatoms. In such a case the conditions for the development for these organisms can hardly be favourable, as some individuals are to be met with everywhere which, if the conditions were favourable, could be the origin of a rich vegetation.

The Oceanic Diatoms which are of some importance in the Norwegian Northern Ocean are not many.

As we will set aside rare species, we need but to take the following 16 species into account:

Coscinodiscus concinnus, W. SM.
„ *oculus iridis*, EHR.
„ *radiatus*, EHR.
„ *stellatus*, ROP.
Rhizosolenia styliformis, BRIGHTW.
„ *semispina*, HENSEN.
„ *Shrubsoli*, CL.
„ *alata*, BRIGHTW., *f. gracillima*
„ *obtusa*, HENSEN.
Chætoceros boreale, BAIL.
(including *Ch. Brightwellii*, CL.)
„ *criophilum*, CASTR.
(including *Ch. convolutum*, CASTR. = *Ch. Brightwellii*, GRAN, which is however regarded, by GRAN, as a different species).
„ *currens*, CL.
„ *atlanticum*, CL.
„ *decipiens*, CL.
Thalassiothrix Frauenfeldii, GRUN.
„ *longissima*, CL. & GRUN.

It would not appear as if all of these species were favoured by the same outward conditions. As a rule not more than one or some few species are to be met with in quantities, whilst the others then are but secondary elements of the Plankton.

It is this circumstance, which gave CLEVE the idea of separating his types of Oceanic Plankton (see *inter alia* [97], p. 4), which we in the following enter into at greater length. There are especially five species which can appear in such numbers as to give the Plankton its character; namely

Coscinodiscus oculus iridis
Thalassiothrix longissima
Chætoceros decipiens
Rhizosolenia styliformis
Rhizosolenia alata (f. gracillima).

Those hydrographical conditions which in different instances gives one of these species the priority of the others, have not yet been investigated. In many cases the temperature appears to play an important part, even if this is not *per se* capable of explaining everything.

The *Coscinodiscus* species, thus occur on our shores, especially during the coldest period of winter; after these come *Thalassiothrix*, and somewhat later on the Oceanic *Chætoceros* species, whilst *Rhizosolenia styliformis*, arrives with the Atlantic current during the summer and autumn, and *Rh. alata* thrives best in the very warm surface layers which the Baltic current conveys along the coast (see Table 1) during summer.

The results derived from the two "Heimdal" expeditions in May 1896 and 1897, also agree with the above.

The distribution of the Plankton is graphically described on Pl. 4, in the Hydrographic Profiles.

Under each Hydrographic Station will be found two columns, of which the first, on the list, denotes the surface Plankton, the other, the contents of a sample taken in a net drawn perpendicularly to the surface from a depth of 100 metrès. The Oceanic

species are coloured blue, the Neritic red (Southern), brown (Northern) and green (Arctic).

The tones of the colours denote the approximate quantity of the corresponding species, the name of which will he found at the left, just beyond the horizontal lines. The tones correspond with the 4 markings given hy CLEVE, r (lightest), + (2 tones), c (3 tones), cc darkest tints. Of the green colouring there will he found but the two lightest shades, and of the brown hut the three lightest.

It must be stated that CLEVE's markings, which we have, hitherto, adopted in all our investigations, hut form a very small scale for the comparison of the quantitative distribution of the species in the samples. The indication cc, corresponds to a frequency which is at least 1000 times greater than denoted by r. Neither the Tables, nor the graphic deliniation on Pl. 4, give, therefore, an adequate idea of the diversity, which, in reality, is very great.

On Pl. 4, it will he seen that the temperature in 1896, increases from the coast outwards towards the bodies of water in the Gulf Stream, after which it gradually decreases as it approaches the Polar current. The same was the case in 1897, with the exception that the temperature was, throughout, about 2° lower, owing to the greater development of the Polar current.

In 1896, the Oceanic Diatoms were so distributed that *Chætoceros decipiens* attained its maximum at St. V (surface temperature 9°.6), *Thalassiothrix longissima* hetween St's. VII and VIII (Temperature respectively 6° and 5°.2), and *Coscinodiscus oculus iridis* at St. VIII (Temperature 5°.2). The *Rhizosolenia styliformis* was not met with at any of the stations in great numbers. It attains its greatest development somewhat later in the summer when the water has become more heated.

In May 1897, none of the species had become developed to any appreciable extent.

We thus see that each individual species attains its maximum at different places, and under different conditions of life. Probably it is the temperature which has the greatest influence on their development.

As the various Oceanic currents do not afford the organisms like conditions of existence, the Plankton may, in many instances, be employed as a means of distinguishing waters of different origin.

The Diatoms may easily be observed, especially on account of their occurrence in masses, and their various appearances at various spots may, in many instances, stamp the Oceanic currents.

This is illustrated, too, on Pl. 4, Fig. 1. The Stations II—IV*) are near the Norwegian coast, and the coastal currents with their low salinity go from the surface down to a depth of 60 to 100 metrès.

The Plankton contains scarcely any diatoms, only some individuals of Oceanic species, but, on the other hand, great quantities of peridins, (especially *Ceratium tripos* and the variety *longipes*, which however is not separated from the main species).

Stations V—VII**) are situated in the waters of the Gulf Stream, as will be seen from the dark blue colours on the profile (salinity exceeding 35 ‰).

*) On the Tables, Stations 42—45.

**) On the Tables, Stations 46, 50, 54.

The samples of Plankton contained masses of Diatoms, and no appreciable difference existed between the surface Plankton (1st column) and that of the deep (2nd column). Amongst the Oceanic species, not a few Neritic species were met with, which in such salt water found favourable conditions of growth. They would probably, however, have proceeded further with the current for a short time, as most of them possessed numerous spores. *(Chætoceros cinctum, constrictum, diadema).*

At Stations VIII—IX, the Atlantic water was covered by fresher Arctic Ocean water (light blue colouring), which, however, then formed hut a layer of about 80 metrès in thickness. The Plankton there was poorer hoth in quantity and quality. The Neritic Diatoms were entirely wanting, and the Oceanic were somewhat scarce on the surface, whilst met with still in great numbers in the samples taken from a depth of 100 metrès to the surface. In procuring these samples the net was thus drawn through partly Atlantic water.

Stations X—XI, furnished an excessively poor Plankton yielding hut quite few individuals of the most hardy forms. In the Arctic Ocean water therefore, the Diatoms had not at that period of the year commenced their development.

In May 1897 (Pl. 4, Fig. 2) the Arctic Ocean water was still very deficient in organisms, and even in the Gulf Stream, the development was delayed on account of the cooling influence of the Polar current.

From these examples it will be seen that a study of the Plankton, together with purely hydrographical investigations, may be of great value in discerning layers of water of different sources of origin, in the present instance too, the water in the Norwegian coastal currents, the Gulf Stream and the Polar current.

In other instances, however, the Plankton gives but little information concerning the Ocean currents. Thus, for instance, both the Gulf Stream and Polar current are very deficient in Diatoms. This will he seen, for instance, if Table 7 be compared with the corresponding Tahle B III (Fig. 11), or with the profile Pl. 5, Fig. 1. The species which occur are the same in both currents, while no considerable quantitative difference can be observed.

If the investigations in respect to the Plankton are to be employed to any great extent as hydrographical aids, the life and distribution of the Plankton organisms must he first thoroughly known, as, otherwise, hasty conclusions might be drawn from them.

Firstly, the Oceanic Plankton changes its character with the seasons, just as does the life of plants and animals on the coasts, so that the same current at different periods of the year can convey with it different organisms, for instance into the North Sea.

Secondly, the very same current becomes gradually chilled or heated during its course; possibly also undergoes slight changes in its salinity and gaseous contents. On Pl. 4, Fig. 1, it will thus be seen that the temperature and salinity of the Gulf Stream decrease as its waters approach the Polar current.

Such changes will, no matter how gradually they occur, affect the nature of the Plankton, as they retard the development of some species, and promote that of others which possibly may have, previously, appeared in such small numbers, as to have escaped

attention, or which, as regards some individuals, have entered the waters from adjacent currents.

In this way one can, in any case, most easily explain the gradual changes in the composition of the Plankton, as we know it, from the great oceanic currents, especially the Gulf Stream (see J. Murray 97).

It is, therefore, necessary to make fuller investigations respecting the extent to which the Plankton organisms can travel in that stratum of water to which they belong, without their being destroyed by the change of conditions.

According to Petersen's investigations, the various organisms do not possess equally great powers of standing such changes. Whilst large animals, such as the medusa *Pilema octopus* are carried along alive, during Autumn, with the bodies of water which flow from the North Sea into the Lim Fjord, and also whilst *Noctiluca* is carried in, in great numbers, the Diatoms of the North Sea (during the Autumn *Rhizosolenia styliformis)* only come as far as the nearest station at the entrance of the Fjord.

As the water invariably flows from the North Sea through the Lim Fjord to the Cattegat, the Diatoms arriving from the North Sea must perish in the western portion of the Lim Fjord.

In the central part of the Lim Fjord they are replaced by a rich Neritic Flora, which, however, in its turn, cannot proceed further with the water to the Cattegat, but sinks to the bottom before it reaches the eastern mouth of the fjord.

Thus in the Lim Fjord the movement of the Diatoms is limited to a most considerable extent. In that fjord the conditions of life become changed with great rapidity, as, for instance, the salinity*) can decrease from 30.4 ‰ (Station 2) to 25.8 ‰ (at the eastern Station).

In the open sea, the Diatoms might well traverse very great areas

Our greatest interest is centred in our acquaintance with the changes that take place in the ocean currents along the coasts where our great fisheries exist. And when the oceanic bodies of water approach the land they must undergo hydrographic changes which are sufficiently great to change their Diatomic flora.

Contact with the bottom, and with other currents must, there, supply the waters with the germs of a new Plankton, which, in such a case, develop rapidly. Several observations have been made which indicate that the Plankton increases in bulk where various oceanic currents meet (see, amongst others, Petersen [98] pp. 14, 15; Vanhöffen [96], and our own observations from the West Coast, Table 5).

In individual cases it may, therefore, be very difficult to determine which forms have been carried in with the oceanic currents, and which have been previously latent, as spores on the bottom or single individuals floating in the coastal current.

Of late, Swedish scientists have come to tolerably advanced conclusions respecting the distribution of the Plankton, and, mainly on these, built their hypotheses of the system of currents of the North Atlantic.

*) Petersen [98] Table 1

Their views have been given in several works; first in those of Aurivillius [96], based on the animal Plankton, subsequently in those of Cleve [97] which are based exclusively on the distribution of the Diatoms. Various phases of the hypothesis have, moreover, been discussed in the writings of Cleve, Ekman, Hjort and Pettersson [97], concerning the condition of the Skagerak during the period of the Herring fishing, and also in Pettersson and Ekman's two last treatises on the subject [97 and 98].

The hypothesis may, shortly, be indicated by saying that, the layers of water in the North Atlantic move between each other without becoming mixed to any great extent, except in the shallows on the coast. They can be recognised by their Plankton organisms, just as geological strata are distinguished by their leading fossils.

When those various types of Plankton, which in Summer are to be met with in different geographical areas in the North Atlantic and on its seaboard, occur, periodically, in consecutive order in the Skagerak, this is contingent upon the various layers of water flowing in from each its geographical pale.

The southern Neritic species which frequent the Skagerak in September, October and November, should thus enter it from the southern portions of the North Sea along the coast of Jutland together with oceanic forms from the eastern parts of the Atlantic.

In November, some northern Neritic forms ought to arrive, probably from the Norwegian coast, as well as Central Atlantic forms (the so-called Chæto-Plankton); in December, West Atlantic oceanic species (Tricho-Plankton), and, in February, Oceanic and Neritic species from the coast of Greenland (Sira-Plankton), which must, through the increased bulk of the Polar current, be conveyed right across the Gulf Stream.

During the course of the spring, these are surplanted by the Central Atlantic Plankton, and Neritic forms from northern shores, and, during the summer, the East Atlantic species reappear in the deeper strata, whilst the organisms of the Baltic current (Tripos Plankton) fill the less saline waters of the surface.

In his last great and comprehensive work, Aurivillius gives a description of the Animal Plankton of the Skagerak, from the study of which he has arrived at similar results, which we will refer to in our concluding remarks.

We will now enter more fully into Cleve's hypotheses, in order to see whether they, in our opinion, can be maintained.

Cleve recognises the following types of Plankton.

Oceanic Types

1. Sira-Plankton	(symbol Si).		Typical forms		*Thalassiosira Nordenskiöldii* *Coscinodiscus oculus iridis*
2. Tricho-Plankton	—	T	„	„	*Thalassiothrix longissima* *Rhizosolenia semispina*
3. Chæto-Plankton	—	C	„	„	*Chætoceros decipiens* — *boreale*

4. Styli-Plankton	(symbol S).	Typical forms		*Rhizosolenia styliformis*
5. Tripos-Plankton	— Tp	„	„	*Ceratium tripos, Rhizosolenia alata f. gracillima*

Neritic Types

1. Southern Neritic Plankton	(symbol Nm).	Typical forms		*Chætoceros didymum*
2. Northern Neritic Plankton	— Ns	„	„	*Skeletonema costatum, Leptocylindrus danicus*
3. Arctic Neritic Plankton	— Ng	„	„	*Chætoceros furcellatum. Fragilaria oceanica*
4. Concinnus Plankton	— Nc	„	„	*Cosciuodiscus concinnus*
5. Halosphæra Plankton	— Nh	„	„	*Halosphæra viridis*

We will first refer to the Oceanic Types.

As we have already stated, the conditions in the open sea are similar throughout great stretches of ocean, and it commonly happens that one species predominates to such an extent as to determine the nature of the Plankton. Therefore such a classification as that made out by CLEVE is practical and applicable in many instances, even if one differs from him in the hypotheses attached to it.

Before proceeding further, we would remark that CLEVE's type, Sira-Plankton, includes Oceanic *(Coscinodiscus)* and Neritic *(Thalassiosira)* forms. For the oceanic, one ought therefore to establish a new type, Disco-Plankton, and place Sira-Plankton amongst the Neritic forms.

With this change, CLEVE's 5 types naturally embrace the 5 Pelagic Diatoms which, also, from our observations, most generally occur as prevalent species in the Plankton.

We thus get:

1. Disco-Plankton — *Coscinodiscus oculus iridis*
2. Tricho-Plankton — *Thalassiothrix longissima*
3. Chæto-Plankton — *Chætoceros decipiens*
4. Styli-Plankton — *Rhizosolenia styliformis*
5. Tripos-Plankton — *Rhizosolenia alata*

A deciding question as to the correctness of CLEVE's hypothesis concerning the movements of the Plankton may be put, viz., whether a type of Plankton — or Plankton community if we may use a term employed for the fixed plants — cannot become spread in other ways than by means of the ocean currents. If CLEVE's theory were right, it surely ought to be proved that the Diatomic communities cannot spring up to any great extent in parts remote each other. even if the natural conditions were similar. In such a case one might, justifiably talk, for instance, of Chæto-water and Tricho-water, in which the organisms could be regarded in the same light as leading fossils in geological strata.

The Swedish scientists have not endeavoured to being forward any proof, of this being so, and, in reality, such could not be done. On the contrary, CLEVE's own tables shew us the possibility of such independent development.

If but quite small numbers, for instance of Chæto, Disco and Tricho Plankton species could be found amongst an abundant Styli-Plankton, the possibility is raised of the other species becoming gradually developed at the expense of the Styli-Plankton when the waters cool or possibly undergo other, but hitherto unknown hydrographical changes. The opposite would occur by an increase of warmth, and even in the Polar current itself a Styli-Plankton might gradually become developed provided it contained some individuals of *Rhizosolenia styliformis* which had survived the cold, or which might enter it from adjacent currents.

If we regard CLEVE's Table I [97] in which he has placed a number of, in his opinion, typical samples of Styli-Plankton from the most different portions of the Atlantic, we will perceive that in the 12 samples the following were met with.

Styli-Species	*Rhizosolenia styliformis* .	was found in	10	samples	
Chæto- —	*Chætoceros boreale*	„	„ -	4	—
	— *decipiens*	„	„ -	6	—
Tricho- —	*Thalassiothrix longissima*	„	„ -	5	—
	Rhizosolenia semispina ..	„	„ -	3	—
Tripos- —	*Rhizosolenia gracillima* .	„	„ -	4	—

In Table II, 7 Types of Chæto-Plankton

Chæto-Species	*Chætoceros boreale*	was found in	7	samples
	— *decipiens*	„ „ -	7	—
Disco- —	*Coscinodiscus oculus iridis* .	„ „ -	1	—
Tricho- —	*Thalassiothrix longissima* ..	„ „ -	5	—
	Rhizosolenia semispina	„ „ -	4	—
Styli- —	— *styliformis* ...	„ „ -	5	—
Tripos- —	— *gracillima* ...	„ „ -	4	—

Of Tricho-Plankton, p. 6, 10 Typical samples

Tricho-Species	*Thalassiothrix longissima* ..	was found in	6	samples
	Rhizosolenia semispina	„ „ -	5	—
Disco- —	*Coscinodiscus oculus iridis* .	„ „ -	2	—
Chæto- —	*Chætoceros boreale*	„ „ -	3	—
	— *decipiens*	„ „ -	2	—
Styli- —	*Rhizosolenia styliformis* ...	„ „ -	3	—

It will be seen that even in these samples which CLEVE himself has chosen, there are sufficient of the other Plankton Communities to allow of their becoming developed when a change in the conditions of existence occurred.

In nature, the communities are, in most instances, even still more mixed, even when one predominates. If one refers to our Pl. 4, Fig. 1, it will be seen that at Station V, the Chæto-Plankton predominates, with Tricho- and Disco-Plankton in a subordinate degree. At Station VI, the same exists. At Station VII the three Oceanic types are equally developed. At Station VIII, the Disco- and Tricho-Plankton predominates, with Chæto- and Styli-Plankton to a subordinate extent.

At Station IX. the Tricho-Plankton predominates, the three other communities only in a subordinate degree. At Station X very small quantities of both Tricho-, Disco- and Chæto-Plankton are met with, but none of them predominating.

It was the same at the following Stations which were established at different spots in the sealing area. Such solitary members of the various Oceanic Diatoms are to be met with almost everywhere throughout the North Atlantic Ocean at all seasons of the year.

Thus VANHÖFFEN [97], during midwinter, up the Karajak Fjord in West Greenland, found solitary individuals, at one time of the *Chætoceros decipiens, boreale* or *atlanticum*, at another of the *Rhizosolenia styliformis* or *semispina*, and also of the *Coscinodiscus oculus iridis* and *radiatus*.

It was all a chance whether the net brought up one or other of these species, as they were very scarce (see VANHÖFFEN's Table 1 c, p. 288, and GRAN [97, 2]). There is thus nothing to prevent our assuming that the various Oceanic Diatomic communities can become developed independently in quite different localities.

From this it is conclusive that the distribution of these communities cannot be employed in forming conclusions concerning the connection of currents through widely separated tracts of Ocean. The Typical forms in CLEVE's Types are so widely spread that their occurence in masses cannot, as a rule, indicate those parts of the ocean in which the stratum concerned originated.

At short distances, where the hydrographical conditions are not allowed time to change, the Plankton may, however, yield very important information. Thus it is known that great quantities of cuttle fish and medusæ are conveyed, during the Autumn, to the Skagerak from the North Sea and English Channel.

These large animals have greater powers of resistance than the one-celled Diatoms, but the same current carried with it too, an abundance of Styli-Plankton, which contained marked southern forms. Thus, the Oceanic *Rhizosolenia robusta*, *Norm.*, was found off Langesund on the 5th November 1897. It is common in the Mediterranean but not met with previously in a higher northern latitude than off Plymouth.

But such migrations of the Plankton communities can only be deemed possible, provided the conditions of life remain somewhat unaltered. On lengthy journeys, the conditions become changed — we need only to look at the charts to see how the temperature of the Gulf Stream drops as it approaches the North — and the Plankton organisms be surplanted by other species.

It is quite another matter that, owing to the Diatoms being very sensitive to hydrographical variations, the investigation of the Plankton, combined with readings of temperature and chemical re earch, becomes a means of studying the hydrography of the various ocean currents.

Thus, inter alia, our Pl. 4, shews that two adjoining ocean currents can possess a very different Plankton.

But as the Plankton organisms are dependent on the hydrographical relations (temperature, salinity) they cannot enlighten us on any point other than what we also could discover by accurate hydrographical investigations.

Given equal conditions, the same Plankton organisms will become developed provided the necessary germs are present, and this fact as a rule holds good in respect to the Pelagic Diatoms.

In respect to the Neritic Diatoms the conditions are much more complicated, as they possess many more species. CLEVE recognises 5 types.

1. Didymus-Plankton or Southern Neritic Plankton (Nm) Typical Forms
   Chætoceros didymum
   — *curvisetum*
   — *Schüttii*
   Biddulphia mobiliensis, and others
2. Northern Neritic Plankton (Ns) with its Typical Forms
   Leptocylindrus danicus
   Skeletonema costatum
   Chætoceros laciniosum
   Lauderia annulata
3. Arctic Neritic Plankton (Ng)
   Achnanthes taeniata
   Fragilaria oceanica
   Chætoceros furcellatum
   Thalassiosira hyalina
4. Concinnus-Plankton (Nc)
   Coscinodiscus concinnus
   Biddulphia mobiliensis
5. Halosphæra-Plankton (Nh)
   Halosphæra iridis

To which must be added

6. Sira-Plankton
   Thalassiosira Nordenskiöldii
   — *gravida*
   Chætoceros diadema
   — *sociale*

CLEVE has included this in the Oceanic Disco-Plankton.

All these Neritic types of Plankton, which at different times are met with in Skagerak, are supposed to be in constant movement with the currents, but none of them are said to proceed from the Skagerak itself. CLEVE says ([97] p. 3) "These Neritic forms move with the currents along the coasts, and I believe there are no stationary species among them."

Thus Type No. 1 (Nm) is presumed to enter the Skagerak from the southern parts of the North Sea; No. 2 (Ns) from the West Coast of Norway; No. 3 (Ng) belongs to the Arctic shores of Greenland and Spitzbergen; No. 4 and 5, the North Sea, and the Sira-Plankton, it is presumed, comes from the Coast of Greenland.

None of the Types therefore are supposed to belong to the Skagerak itself, and yet there is found there a greater mass of Neritic Plankton than is to be met with at any other spot on the seaboard of the North Sea or Northern Ocean. It is only the Cattegat and the Lim Fjord that possesses Neritic Plankton in greater abundance.

As all these species are really coastal forms, as CLEVE himself has found out, is it *a priori* very improbable that not one single species belongs to the shores of the Skagerak. And on closer observation of the individual types this shews itself still more clearly.

The first Neritic community, the Didymus-Plankton (Nm), occurs in the Skagerak during summer and autumn when the water is warm. In like manner we meet with the Sira-Plankton (Si) when the temperature is at its lowest in the months February to April.

There are thus two annual maxima in the Neritic Plankton. The one, during the warmest time of the year, formed of species which are most widely diffused on more southern shores *(Chætoceros didymum, Schüttii, Weissflogii, Ditylum Brightwelli, Biddulphia mobiliensis* &c.); the other, which attains its maximum during the coldest season of the year, formed of northern species, *Thalassiosira gravida, Nordenskiöldii, Coscinodiscus polychordus, Chætoceros debile, diadema, socialc, Biddulphia aurita.* On the colder, northern shores (Greenland, Spitzbergen), where these species may be met with in great numbers, they attain their maximum during the warmest months of summer.

It is not alone the Plankton Diatoms that have two such annual periods. A like phenomenon is to be found amongst, for instance, the higher Marine Algæ.

The annuals amongst these are, either the summer forms which develop during the summer, and fructify during the autumn (for instance *Nemalion multifidum, Dictyota dichotoma. Cutleria multifida, Delesseria ruscifolia, Cystoclonium purpurascens, Polysiphonia byssoides),* or the winter forms which fructify during the spring *(Scytosiphon lomentarius, Dumontia filiformis,* and the *Monostroma* species). Also in respect to these it is certain that the Winter Flora chiefly consists of northern species; the Summer Flora, of forms which attain their maximum development in warmer seas.

The Stationary Diatoms too attain their greatest development at the same seasons, and can then cover the algæ of the littoral with a close brown felt.

All these forms are undoubtedly stationary. As crusty coverings to stones and rocks, they lie dormant during the unfavourable seasons.

It appears to us to be most natural to assume the like in respect to the Neritic Diatoms, when we know that they have the power of forming spores which fall to the bottom. Through PETERSEN's investigations in the Lim Fjord we have besides proof that the Neritic Diatoms may be stationary.

CLEVE's Type 2 (Ns), is composed of forms, which, in his opinion, come from the West Coast of Norway. He, however, says ([97] pp. 7, 8) that he is not from personal experience, acquainted with the Plankton of the Norwegian coast, but only draws his conclusions from the appearance of the species in the Skagerak. CLEVE does not give any reason on which to base this assumption, which is, in any case, erroneous, as none of those species are typical of the Norwegian West Coast. They are all to be met with there at various seasons, but only as subordinate constituents of the Plankton.

This can be seen from our Tables (1, 3 & 5) and from CLEVE's later researches, mentioned in PETTERSSON and EKMAN's work [98].

The typical forms on the West Coast of Norway are, as we have already indicated, on the whole the same as those of the Skagerak. As is usually the case with the fauna and flora of neighbouring coasts, the Neritic Plankton in both places contains most of the species in common, and the difference mainly consists in the relative numbers of the species being altered. The 4 species that are named are at least as common in the Skagerak as on the West Coast, and there, therefore, exists no reason for withdrawing them from the others and placing them in a separate group.

This theoretically constructed Plankton group must, therefore, in any case in its present form, be abandoned. If it is to be replaced by any other, the West Coast Flora must be divided into many communities, as the Plankton there, just as in the Skagerak, changes with the seasons.

Such a division we however consider to be of little consequence so long as we do not know more of the development and life of the Neritic Plankton.

CLEVE's other three types, the Arctic Neritic Plankton, Concinnus-Plankton and Halosphæra-Plankton we will treat of shortly. The first is a well defined community of high Arctic forms which vegetate during winter along the whole of our Northern Ocean shores (southern limit at Stadt), and which during summer are but met with on the coasts of Greenland and Spitzbergen.

The Concinnus-Plankton and Halosphæra-Plankton are presumed to belong especially to the North Sea. We do not possess sufficient materials to form an opinion on the correctness or otherwise of adjudging these to be separate communities.

The *Coscinodiscus concinnus* we have deemed to be Oceanic on account of its close relationship to *C. oculus iridis.* From G. MURRAY's investigations, which we unfortunately are only acquainted with from the preliminary treatise in the Fishery Boards Report [97], it appears to have spores, so that it may be regarded as truly Neritic.

Halosphæra too, appears to possess a sort of cyst formation*), which, however, has not been more fully investigated. Its range is very great, being met with from the Mediterranean, where it was first discovered, to the Lofotens, and in to the very quays of Christiania.

We cannot here enter more fully into the various forms of the Neritic Plankton. If these organisms are to be divided into communities, one would have to arrange the species in groups, according to each stretch of coast, requiring similar conditions of existence, and attaining their maximum at similar seasons. In order to do this we have yet too little material to go upon, but we do not doubt that this can be done, and, when it is accomplished, that. by comparing the development of the corresponding groups at the various places, we should obtain important contributions towards comprehending the climate of the ocean.

The Neritic Diatom Plankton can, to still less an extent than the Oceanic, give any basis for hypotheses concerning the flow of waters from distant parts.

The Sira-Plankton disappears, for instance, from the shores of Greenland in September, appearing in the Skagerak first in

*) Shortly described in a preliminary note by CLEVE. We also have occasionally met with such formations.

February. If this migrates directly across the Gulf Stream, it must thus take 5 months to perform the journey, and during that period be exposed to great hydrographical changes. It has, however, never as yet been observed on its way, so that there exists nothing whatsoever to allow of our assuming the probability of such a migration.

We, therefore, have come to the conclusion that the Plankton Diatoms cannot be used as indicatory organisms in the comparison of far separated places, as their migratory powers are not great, and the same kinds of Plankton can, in all probability, be developed at different places under like conditions.

With the large animals of the Plankton, matters are, however, very different. The Animal Plankton has been very thoroughly gone in to by AURIVILLIUS, who, especially in his latest great work [98] gives a general account of their relation to the ocean currents.

AURIVILLIUS bases his observations on the Plankton of the Skagerak, which is partly endogenous, and partly allogenus.

The allogenus species he separates into 5 groups.

1. Forms from the Jutland current.
2. Forms from the amalgamated waters in the Northern Ocean.
3. Forms from the northern parts of the Gulf Stream.
4. Forms from the Arctic current.
5. Forms from the Baltic waters.

This classification has been partly founded on the distribution of the species in the Northern Ocean &c., which however, is to some extent but little known, and partly, and especially on their periodical appearance in the Skagerak.

Thus, for instance, the forms in the Jutland current attain their maximum in September—October; those of the Arctic current in February.

The Author, however, says (l. c. p. 127) "Wenn ferner die Erscheinungszeiten der Formen einer jeden dieser fünf binnen Jahresfrist auftretenden Klassen unter sich verglichen werden, so geht hervor, dass sie nicht in der Meinung von einander gesondert sind, dass die eine auftritt, wenn die andere verschwindet oder im Rückgang begriffen ist, sondern vielmehr greifen die Perioden in einander über so dass gleichzeitig bis auf vier Kategorien vertreten sein können. So ist z. B. im Januar der Fall, wo noch einige Formen der Jütschen Strömung zu treffen sind, während dass gleichzeitig alle drei Gruppen nördlichen Ursprungs mehr oder weniger zahlreiche Vertreter haben."

In this, in our opinion, lies the kernel of the question. We consider it as settled that, throughout the year, bodies of oceanic water flow into the Skagerak, especially along the coast of Jutland where the strong current which pours in has long been recognised. And the water must convey with it Oceanic organisms, provided they have sufficient powers of resistance to withstand the changes that occur in the surrounding water.

But we regard it as being doubtful, whether, from the solitary species or group, it is possible to indicate with certainty the pale of sea, or the ocean currents from which they originate.

Two stretches of ocean or land, with not too different a climate, own, as is known, most species in common, whilst but a minority, of most often rare, sensitive forms, are typical of individual spheres.

And even were it possible with certainty to say that certain species but existed, for instance in the Polar current (such as *Calanus hyperboreus*, *Clione limacina)*, one cannot, therefore, either in the North Sea or Skagerak point out certain layers of water as being, or having been direct continuations of the Polar current.

This current shews its influence by giving the northern portion of the Gulf Stream a lower temperature and lesser salinity than elsewhere. We saw on Pl. 4, that the great development of the Polar current, during the winter and spring of 1897, lowered the maximum temperature on the line Sogne Fjord—Jan Mayen (12th—15th May) to 7°.2. whilst in 1896, at the same period it was 9°.6. The Polar current is checked to the north of the Shetland Islands, but as all the Arctic organisms can thrive in water of 5° to 7° (see AURIVILLIUS l. c. p. 87—91), they may be conveyed on in the amalgamated layers to the North Sea and Skagerak.

As AURIVILLIUS, generally finds his geographical groups intermingled, this surely likewise indicates that the waters become mixed, and that it is, thereby, impossible to point out strata of any certain origin.

The oceanic waters which flow into the Skagerak must pass, partly, through the English Channel, partly through the northern entrance to the North Sea, and the Norwegian Channel. The nature of the in-flowing layers are therefore determined by the hydrographical conditions existing in those parts.

There, as everywhere else, the changes of the seasons affect the ocean water and its organisms, so that the temperature, and the Pelagic Fauna and Flora obtain an annual period. This complication alone can, in our opinion, cause great yearly changes in the Plankton of the Skagerak. To this must be added the fact, that the Gulf Stream during winter, in the northern portion of the North Sea, becomes chilled by the proximity of the Arctic current, and that, possibly, its fauna is supplemented with Arctic animals.

The biological conditions can, thus, not affect the results of our hydrographical studies. The general result of the combined investigations we may sum up in the following manner.

Resumé.

The Hydrographical Conditions in the Northern Ocean are determined by three factors, viz., the Gulf Stream, the Arctic Current and the Continent. The influence of each of these factors is subject to annual periods having their maxima and minima.

The Gulf Stream reaches its maximum during the summer. It then attains those dimensions with which we have been made acquainted through the instrumentality of the Norwegian Northern Ocean Expedition. In November it begins to decrease, and by the winter its thickness, both on the surface and down in the deep, diminishes. Whilst it, during summer, covers the greatest portion of the surface of the Northern Ocean, it in winter becomes reduced to a narrow stripe running in the direction SSW to NNE, throughout the central and easterly portions of the Northern Ocean. But, nevertheless, it forms a barrier at all times of the year between the East Iceland Arctic current and the North European coastal sea. In the deeps of the Norwegian coast the annual period is seen through its being met with, during summer, up to 50 metrès below the surface, whilst, during winter, it sinks to a depth of 200 to 250 metrès.

In addition to the annual period, the Gulf Stream, according to our investigations, likewise undergoes changes from one year to another, but we cannot, from the materials to hand, determine whether these variations are connected with a great period or not.

The eastern branch of the Arctic current (to the eastward of Iceland) is forced back during the summer, so that it but reaches the south eastern point of Iceland. During winter, on the other hand, it attains so great dimensions, during March and April, as to occupy the whole of western portion of the Northern Ocean from the surface down to a depth of at least 2 to 300 metrès. During this period, as in 1897, it can descend so far in a SSE direction, as to be separated from the Shetland Islands by but one degree of latitude. There, however, its course is always checked by the northern branch of the Gulf Stream, but probably a great admixture of their waters occurs.

This current too, is subject to great changes from year to year, and these changes are most closely connected with corresponding changes in the Gulf Stream.

The Coastal Water, along the entire coast of Norway, undergoes the same annual periodical changes as previously described by Hjort [95]. The most striking phenomenon in this period is the increasing thickness of the coastal water during the autumn and winter, whilst the Gulf Stream is simultaneously forced down towards the bottom. From our investigations, this expansion is chiefly caused by the mixing of Atlantic water with fresh water from the continent, and not by the addition of water from the Arctic Ocean, as is assumed by Pettersson and Ekman.

The Plankton. In the foregoing pages we have given an account of the various kinds of vegetable Plankton existing on the shores of Norway, and the annual periodicity in the occurrence of the individual Plankton organisms.

Of more general interest are our enquiries into the causes of this periodicity. It is caused on the one part by the stationary coastal forms' dependence on the physical and chemical conditions necessary to life, as individual species flourish under those specific conditions which favour them, and fall to the bottom in a dormant state so soon as those conditions are absent. On the other part, the ocean currents convey oceanic organisms from adjacent portions of the North Atlantic. The fate of these organisms is too, both in the ocean and the coast, entirely dependent on hydrographical changes.

Their occurence on the coast is thus dependent, partly, on the hydrographical condition of the eastern branch of the Gulf Stream, and partly, on the conditions present on the coast itself.

As all the inflowing bodies of oceanic water are of an Atlantic kind, the Arctic organisms, which may be met with at certain times, must, in any case, pass through Atlantic water if they really are derived from the Arctic current, but their subsequent appearance, in the colder and fresher water on the coast, is no proof of the coastal water's Arctic origin.

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HYDROGRAPHICAL TABLES

A. Summer time.

I. Sections off the Norwegian coast June and July 1895.

a) Section off Stavanger.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
	June			58°27′.5		Meter				
1	22	9.15 a.m.		4°16′.5		0	12°.20	17.36	31.41	30.71
						5	12 .00	17.68	32.00	31.26
						10	11 .50	17.74	32.09	31.37
						15	9 .60	18.83	34.05	33.20
						18	9 .70	18.83	34 05	33.20
						20	9 .80	19.22	34.75	33.88
						30	5 .60			
						40	5 .40	19.62	35.47	34.56
						60	5 .80	19.93	36.02	35.11
						80	6 .20	19.93	36.02	35.11
						120	5 .70	20.08	36.24	35.35
						160	5 .80	20.08	36.24	35.35
				58°46′						
2	22			4°35′		0	12 .60	17.68	32.00	31.26
						5	12 .20	17.75	32.11	31.39
						10	11 .50	18.30	33.10	32.32
						15	8 .80	18.64	33.71	32.90
						20	6 .60	18.96	34.29	33.44
						40	6 .60	19.38	35.03	34.16
						60	5 .80	19.67	35.56	34.66
						80	6 .00	20.03	36.17	35.26
						120	6 .30	20.08	36.24	35.35
						200	6 .00	20.08	36.24	35.35
						280	5 .80	20.08	36.24	35.35
				59° 5′						
3	22			5°18′		0	11 .80	16.91	30.60	29.92
						10	12 .00	16.91	30.60	29.92
						15	11 .80	17 00	30.77	30.10
						20	11 .60	17.10	30.94	30.26
						30	11 .50	17.68	32.00	31.26
						40	9 .20	18.65	33.68	32.86
						60	7 .20	19.43	35.12	34.25
						80	5 .80			
						120	5 .90	19.97	36.08	35.16
						200	6 .00	20.06	36.22	35.31
						360	6 .00	20.06	36.22	35.31

b) Section off Marstenen beacon near Bergen.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
				60° 7′						
4	26	2 a.m.		4°28′		0	10°.90	18.17	32.83	32.06
						20	11 .00	18.28	33.06	32.28
						40	6 .80	19.60	35.42	34.53
						60	6 .60	19.70	35.61	34.69
						80	6 .40	19.89	35.96	35.04
						130	7 .00	19.89	35.96	35.04
				60° 9′						
5	26			5° 4′		0	12 .00	17.37	31.43	30.73
						10	11 .10	19.60	35.42	34.53
						20	6 .00	19.60	35.42	34.53
						30	6 .00	19.63	35.51	34.61
						40	6 .00	19.86	35.89	34.96
						60	6 .10	19.88	35.93	35.01
						80	6 .25	19.88	35.93	35 01
						120	6 .25	19.87	35.91	35.00
						200	6 .25			

c) Herlöfjord.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
				60°29′.5						
6	27			5°14′		0	14°.25	11 08	27.43	26.90
						5	10 .90	15.15	27.43	26.90
						10	7 .73	18.07	32.68	31.93
						15	6 .22	18.75	33.91	33.09
						20	5 .35	18.94	34.26	33.42
						30	5 .77	19.43	35.12	34.25
						40	5 .98	19.53	35.30	34.40
						60	6 .14	19.62	35.47	34.56
						80	6 .13	19.62	35.47	34.56
						120	5 .96	20.01	36.16	35.23
						300	5 .65	20.01	36.16	35.23

d) Section off Christianssund.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
	July			63°55′		Meter				
7	2	7½ a.m.		5°52′		0	10°.90	19.35	34.98	34.12
						10	10 .95	19.50	35.25	34.36
						20	9 .46	19.60	35.42	34.53
						30	5 .96	19.55	35.32	34.45
						40	6 .00	19.84	35.86	34.95
						60	6 .16	19.89	35.96	35.04
						80	7 .50	20.10	36.28	35.37
						120	7 .29	20.22	36.49	35.59
						200	6 .12	20.26	36.53	35.64
						300	5 .88	20.26	36.53	35.64
				63°33′						
8		11.20 a.m.		6°20′		0	11 .20	19.41	35.08	34.21
						10	10 .85	19.60	35.42	34 53
						20	9 .05	19.70	35.61	34.69
						30	8 .25	19.80	35.79	34.88
						40	7 .75	19.99	36.15	35.20
						60	7 .48	20.13	36.34	35.43
						80	7 .40	20.13	36.34	35.43
						120	6 .86	20.18	36.40	35.51
						200	6 .72	20.22	36.49	35.59
						300	6 .70	20.22	36.49	35.59
				63° 9′						
9		3 p.m.		6°37′		0	11 .55	19.22	34.75	33.88
						10	10 .95	19.26	34.81	33.95
						20	8 .35	19.32	34.92	34.06
						30	5 .85	19.45	35.16	34.28
						40	4 .92	19.47	35.19	34.32
						60	5 .56	19.89	35.96	35.04
				63° 3′.5						
10		6¾ a.m.		7° 6′.5		0	11 .95	19.05	34.44	33.62
						10	10 .10	19.05	34.44	33.62
						20	8 .20	19.26	34.81	33.95
						30	6 .20	19.45	35.16	34.28
						40	5 .80	19.50	35.25	34.36
						60	5 .60	19.80	35.79	34.88
						80	5 .70	19.99	36.15	35.20
						120	5 .95	20.05	36.21	35.30

e) Section off Vigten.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
				64°42′						
11	5	3½ p.m		9° 8′.5		0	10°.90	19.87	35.91	35.00
						10	10 .90	19.93	36.03	35.11
						20	10 .15	19.97	36.08	35.16
						30	8 .65	20.07	36.22	35.31
						40	7 .60	20.10	36.28	35.37
						60	6 .20	20.10	36.28	35.37
						80	5 .76	20.17	36.47	35.49
						150	5 .18	20.21	36.52	35.56
				64°40′.5						
12		8 p.m.		9°51′		0	11 .08	19.41	35.08	34.21
						10	11 .05	19.64	35.52	34.62
						20	9 .25	19.83	35.85	34.92
						30	7 .52	19 87	35.91	35.00
						40	7 .26	20.00	36.14	35.21
						60	6 .23	20.03	36.17	35.26
						80	7 .50	20.04	36.19	35.28
						120	6 .60	20.13	36.34	35.43
						200	5 .26	20.20	36.50	35.54
				64°41′ 5						
13	7	9 a.m.		10°42′		0	11 .40	18.92	34.23	33.38
						10	10 .35	19.22	34.75	33.88
						20	8 .02	19.39	35.04	34.18
						30	7 .25	19.45	35.16	34.28
						40	6 .30	19.49	35.23	34.34
						60	5 .40	19.63	35.51	34.61
						80	4 .85	19.83	35.85	34.93
						120	4 .62	19 87	35.91	35.00
						200	5 .25	19.87	35.91	35.00

f) Section off Bodö—Röst.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
				67°33′						
14	9	8½ a.m.		9 31′		0	10°.60	19.50	35.24	34.37
						10	10 .30	19.50	35.24	34.37

No.	1895 Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
f) Section off Bodö—Röst (continued).										
	July					Meter				
						20	8°.90	19.82	35.85	34.92
						30	6 .88	19.93	36.01	35.10
						40	5 .93	19.89	35.95	35.03
						60	5 .40	19 93	36.01	35.10
						80	4 .95	19.93	36.01	35.10
						120	5 .15	20.01	36.16	35.23
						200	5 .25	20,08	36 28	35.38
				67°31′						
15	9	1.40 p.m.		10°41′.5		0	10 .45	19.50	35.24	34.37
						10	10 .20	19.50	35.24	34.37
						20	9 .25	19.50	35.21	34.37
						30	6 .80	19.74	35.67	34.77
						40	5 .65	19.87	35.92	35.00
						60	5 .35	19.89	35.95	35.03
						80	5 .15	19.93	36.01	35.10
						120	5 .10	20.01	36.16	35.23
						200	5 .15	20.08	36.28	35.38
				67°26′						
16	9	12 midn.		12°30′		0	9 .90	19.41	35.09	34.22
						10	9 .23	19.41	35.09	34.22
						20	6 .70	19.45	35.16	34.29
						30	5 .85	19.74	35.67	34.77
						40	5 .33	19.80	35.78	34.87
						60	4 .50	19.89	35.96	35.04
						80	4 .32	19.89	35.96	35.04
						120	4 .60	19.91	35.99	35.07
						170	5 .10	20.01	36.16	35.23
				67°23′						
17	10	3 a.m.		13°11′.5		0	11 .10	19.41	35.09	34.22
						10	10 .90	19.41	35.09	34.22
						20	10 .25	19.55	35.32	34.44
						30	7 .25	19.74	35 67	34.77
						40	7 .15	19.80	35.78	34.87
						60	5 .60	19.80	35.78	34.87
						80	5 .25	19.89	35.95	35.04
						120	4 .70	19.89	35.95	35.04
						200	4 .75	19.99	36.12	35 20
						300	4 .79	20.08	36.28	35.38
				67°15′						
19	16	a.m.		14°31′.7		0	9 .60	18.13	32.80	32.03
						5	9 .00	18.47	33.40	32.61
						10	8 .40	18.65	33.68	32.86
						20	7 .10	19.18	34 69	33.84
						30	6 .95	19.43	35.12	34.25
						40	6 .70	19.72	35.65	34.76
						60	6 .20	19.95	36.05	35.13
						80	5 .75	20.01	36.16	35.23
						150	5 .50	20.08	36.28	35.38

II. Observations from Nordland summer and autumn 1895.

No.	1895 Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
a) Observations from Lofoten.										
				68°10′ [1]	Meter					
20	20	m.d.		14°34′	150	0	14°.50	18.18	32.87	32.08
						10	14 .20	18.26	33.03	32.25
						20	12 .00	19.04	34.12	33.58
						30	8 .20	19.37	35.01	34.14
						40	6 .95	19.92	36.01	35 09
						60	5 .56	20.01	36.16	35.23
						80	5 .20	20.01	36.16	35.23
						150	6 .10	20,01	36,16	35.23
				67°23′.5 [2]						
21	30	m.		14° 7′		0	13 .50	19.24	34.77	33.91
						10	13 . 2	19.29	34.87	34.00
						15	12 .90	19.37	35.01	31.14
						20	10 .65	19,60	35.42	34.53
						30	8 .50	19.82	35.85	34.93
						40	7 .60	19.84	35.86	34.95
						60	6 .60	20,01	36.16	35 23
						80	6 .20	20,01	36.16	35 23
						120	6 .00	20.07	36.23	35.33
						200	6 .50	20.19	36.42	35.52
				67°20′.5 [3]						
22	30			14°18′		0	13 .60	19.22	34.75	33.88
						10	12 .88	19.26	34.81	33.95
						20	11 .05	19.49	35.23	34.31
						30	8 .95	19.61	35.52	34.62
						40	7 .58	19,88	35.93	35.01
						60	6 .57	20.03	36.17	35.26
						80	6 .20	20,01	36.16	35.23
						120	6 .80	20.07	36.22	35.33
				67°35′ [4]						
23	31			13°54′		0	12 .80	19.33	34.91	34.08
						10	12 .50	19.39	35.04	34.18
						20	10 .40	19.61	35.52	34.62
						30	8 .80	19.80	35.79	34.88
						40	7 .70	19.88	35.93	35.01
						60	6 .60	20.01	36.16	35.23
						80	6 .30	20.01	31.61	35.23
						120	6 .15	20.09	36.28	35.36
						200	6 .00	20.19	36.42	35.52
b) Section of the Vestfjord.										
	Aug.			67°35′						
24	3			14° 3′		0	12°.45	19.21	34.77	33.91
						10	12 .62	19.24	34.77	33.91
						20	12 .20	19.33	34.94	34.10
						30	9 .05	19 66	35.54	34.64
						40	7 .00	19.76	35.72	34.80
						60	6 .58	19.85	35.82	31.92
						80	6 .20			
				67°43′						
25	3	3 p.m.		13°47′		0	13 .00	19.20	34.72	33.87
						10	12 .80	19.25	34.81	33.94
						20	8 .20	19.62	35.47	34.56
						30	7 .05	19.64	35.52	34.62
						40	6 .70	19.78	35.75	34.84
						60	6 .12	19.80	35.85	31.92
						80	5 .92	19.99	36.15	35.20
						120	5 .78	20.05	36.21	35.30
				67°53′						
26	3	6 p.m.		13°27′		0	13 .00	18.75	33.91	33.09
						10	12 .70	18.85	34.07	33.25
						20	9 .10	19.45	35.16	34.28
						30	7 .00	19.62	35.47	34.56
						40	5 .90	19.64	35.50	34.62
						60	5 .40	19.78	35.75	34.84
						80	5 .66	19.95	36.05	35.13
c) Section off Herö.										
				65°59′						
27	13			11°18′		0	14°.00	18.94	34.26	33.42
						10	13 .70	19.24	34.77	33.91
						20	10 .10	19.33	34.91	34.07
						30	9 .20	19.45	35.16	31.28
						40	7 .90	19. 9	35.23	34.34
						60	7 .10	19.60	35.42	34.53
						80	6 .65	19.62	35.47	34.56
						120	6 .60	19.92	36.01	35.09
						200	7 .10	19.92	36.01	35.09

[1]) Hölø in Lofoten. — [2]) Helligvær. — [3]) Stensvær. — [4]) Vestfjorden.

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
c) Section off Herø (continued).										
	Aug.			65°59′		Meter				
28	13			11°52′		0	12°.80	19.04	34.42	33.58
						10	12 .70	19.04	34.42	33.58
						20	12 .65	19.24	34.74	33.91
						30	11 .45	19.31	34.91	34.05
						40	10 .10	19.43	35.12	34.25
						60	7 .40	19.62	35.47	34.56
						80	6 .65	19.70	35.61	34.70
						120	6 .35	19.82	35.85	34.93
						200	6 .50	19.88	35.93	35.01
				65°57′.5						
29	13			12° 7′		0	13 .00	18.65	33.68	32.86
						10	12 .90	18.83	34.05	33.20
						20	11 .75	19.08	34.51	33.65
						30	11 .10	19.24	34.77	33.91
						40	8 .90	19.43	35.12	34.25
						60	7 .15	19.63	35.47	34.56
						80	6 .60	19.66	35.54	34.64
						140	6 .30	19.82	35.85	34.92
d) Observations from Nordland.										
30	18			66° 4′ [1]		0	13 .60	18.85	34.07	33.25
				12°39′		10	13 .05	18.89	34.16	33.32
						20	11 .00	18.94	34.25	33.42
						30	9 .10	19.18	34.69	33.83
						40	7 .75	19.29	34.88	34.00
						60	6 .55	19.47	35.19	34.32
						80	5 .82	19.62	35.47	34.56
						150	5 .60	19.72	35.65	34.76
				67°15′						
31	22			11°40′		0	13 .20	19.24	34.77	33.91
						10	13 .15	19.24	34.77	33.91
						20	11 .58	19.41	35.08	34.21
						30	9 .20	19.51	35.28	34.38
						40	7 .75	19.62	35.47	34.56
						60	6 .98	19.66	35.54	34.64
						80	6 .52	19.70	35.61	34.69
						120	6 .20	19.68	35.75	34.67
						200	6 .30	19.70	35.61	34.69
				67° 8′ [2]						
32	24			14°20′		0	11 .10	17.62	31.88	31.13
						10	11 .10	17.72	32.07	31.35
						20	12 .00	18.95	34.27	33.43
						30	10 .60	19.15	34.62	33.78
						40	8 .60	19.54	35.32	34.42
						60	7 .20	19.64	35.52	34.62
						80	6 .60	19.84	35.86	34.95
						120	6 .30	19.84	35.86	34.95
e) Section off Helligvær—Röst—Vesteraalseggen.										
				67°25′.5						
33	28	12 m.d.		13°37′		0	12°.00	19.08	34.51	33.65
						10	11 .80	19.18	34.69	33.83
						20	10 .85	19.35	34.98	34.12
						30	8 .80	19.49	35.23	34.34
						60	6 .70	19.83	35 85	34.92
						80	6 .30	19.83	35.85	34.92
						120	6 .20	19.87	35.91	35.00
						200	6 .10	20.04	36.19	35.28
				67°29′						
34	28			13° 8′.5		0	11 .45	19.01	34 38	33.54
						10	11 .40	19.35	34.98	34.12
						20	10 .40	19.46	35.16	34.30
						30	7 .45	19.76	35.72	34.80
						60	6 .20	19.87	35.91	35.00
						80	6 .10			
						120	6 .30			
						200	6 .15			

No.	1895 Date	1895 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperatur of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
e) Section off Helligvær—Røst—Vesteraalseggen (continued).										
	Sept.			67°30′		Meter				
35	3			12°35′		0	10°.40	19.35	34.98	34.12
						10	10 .75	19.35	34.98	34.12
						20	10 .60	19.49	35.23	34.34
						30	7 .65	19.63	35.51	34.61
						40	7 .00	19.63	35.51	34.64
						60	6 .40	19.83	35.85	34.93
						80	6 .00	19.83	35.85	34.93
						120	5 .80	19.83	35.85	34.93
				67°49′						
36	3			11° 4′		0	10 .45	19.49	35.23	34.34
						10	10 .40	19.56	35.35	34.47
						20	10 .45	19.56	35.35	34.47
						30	10 .60			
						40	8 .40	19.68	35.58	34.68
						60	7 .20	19.68	35.58	34.68
						80	6 .80	19.81	35.80	34.89
						120	6 .40	19.99	36.15	35.20
				67°56′						
37	3			10°14′		0	10 .00			
						10	10 .00	19.56	35.35	34.47
						20	9 .95	19.56	35.35	34.47
						30	10 .00	19.56	35.35	34.47
						40	9 .20	19.63	35.51	34.61
						60	7 .10	19.80	35.78	34.88
						80	6 .65	19.90	35.98	35.05
						120	7 .00	19.97	36.08	35.16
				67°21′.5[3]						
38	10			14°27′.5		0	10 .40			
						10	10 .42			
						20	10 .00			
						30	10 .15			
						40	9 .80			
						60	6 .80			
						80	7 .60			
f) Section off Saltenfjord.										
				67°13′.5[4]						
39	20			14°13′		0	9°.45	18.18	32.88	32.10
						10	9 .60	18.37	33.22	32.45
						20	9 .80	18.53	33.50	32.69
						30	9 .50	18.59	33.56	32.75
						40		19.17	34.67	33.81
						60	10 .00	19.25	34.81	33.94
						80	10 .00	19.25	34.81	33.94
						120	7 .80	19.60	35.42	34.54
				67°15′ [5]						
40	20			14°31′		0	9 .20	18.18	32.88	32.10
						10	9 .30	18.30	33.10	32.32
						20	9 .30	18.41	33.30	32.51
						30	9 .20	18.53	33.50	32.69
						40	9 .00	18.65	33.68	32.86
						60	8 .60	18.89	34.16	33.33
						80	8 .10	19.36	35.00	34.13
						120	7 .45	19.48	35.21	34.33
				67°16′ [6]						
41	23			14°43′		0	9 .00			
						10	8 .80			
						20	8 .70			
						30	8 .80			
						40	8 .75			
						60	9 .00			
						80	8 .85			
						120	8 .40			

III. Section Sognefjord—Iceland May 1896

taken by Capt. Bie on H. M. S. "Heimdal".

	May			61° 9′.5						
42	12	9 p.m.		3°50 .5		0	7°.00	18.60	33.62	32.80
						10	7 .68	18.60	33.62	32.80
						20	7 .00	18.60	33.62	32.80
						40	7 .20	18.78	33.98	33.15
						60	6°.00	19.68	35.58	34.68
						80	6 .22	19 80	35.79	34.88
						100	7 .45	19.98	36.10	35.19
						150	7 .60			
						200	7 .65	19.98	36.10	35.19

[1]) Near Dönna. — [2]) Beieren Fjord. — [3]) Near Landegode. — [4]) Mouth of the Saltenfjord. — [5]) Saltenfjord. — [6]) Saltenfjord.

No.	1896 Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	May			61°32′		Meter				
43	13	3 a.m.		3° 8′		0	8°.40	18.57	33.60	32.73
						10	8 .40	18.72	33.60	33.01
						20	6 .60	18.84	34.06	33.21
						40	6 .20	19.59	35.42	34.53
						60	7 .00	19.80	35.79	34.88
						80	7 .28	19.80	35.79	34.88
						100	7 .60	19.98	36.10	35.19
						150	7 .65	19.98	36.10	35.19
						200	7 .65	20.02	36.16	35.25
				61°48′						
44	13	7.30 a.m.		2°28′		0	8 .40	19.08	34.51	33.65
						10	8 .40	19.17	34.67	33.81
						20	7 .20	19.69	35.60	34.70
						40	7 .65	19.81	35.80	34.89
						60	7 .80	19.92	36.01	35.09
						80	8 .30	19.95	36.05	35.13
						100	8 .00	19.95	36.05	35.13
						150	8 .00	19.95	36.05	35.13
						200	7 .80	20.02	36.16	35.25
45	13	10 a.m.		15 miles from st. 45		0	9 .10			
				62°20′						
46	13	12 m.d.		1°50′		0	9 .60	20.10	36.28	35.37
						10	9 .40	20.10	36.28	35.37
						20	9 .20	20.10	36.28	35.37
						40	9 .30	20.10	36.28	35.37
						60	9 .00	20.10	36.28	35.37
						80	8 .80	20.10	36.28	35.37
						100	8 .80	20.10	36 28	35.37
						150	8 .60	20.10	36.28	35.37
47	13	2.15 p.m.		15 miles from st. 46		0	9 .40			
48	13	3.45 p.m.		30 miles from st. 46		0	9 .10			
49	13	6.15 p.m.		45 miles from st. 46		0	9 .20			
				63°10′						
50	13	8 p.m.		0°36′		0	8 .40	20.06	36.22	35.32
						10	8 .10	20.06	36.22	35.32
						20	8 .20	20.06	36.22	35.32
						40	7 .80	20.06	36.22	35.32
						60	7 .40	20.06	36.22	35.32
						80	7 .30	20.06	36.22	35.32
						100	7 .00	20.06	36.22	35.32
						150	6 .80	20.06	36.22	35.32
51	13	11 p.m.		15 miles from st 50		0	8 .70			
52	14	1 a.m.		30 miles from st. 50		0	9 .00			
53	14	2.45 a.m.		45 miles from st. 50		0	7 .80			
				63°54′						
54	14	5 a.m.		0°52′ W.		0	6 .40	19.90	35.98	35.05
						10	6 .20	19.90	35.98	35.05
						20	6 .30	19.90	35.98	35.05
						40	6 .20	19.90	35.98	35.05
						60	5 .60	19.90	35.98	35.05
						80	4 .80	19.90	35.98	35.05
						100	4 .70	19.90	35.98	35.05
						150	4 .60	19.90	35.98	35.05
						200	4 .20	19.90	35.98	35.05
55	14	7.30 a.m.		15 miles from st. 54		0	6 .50			
56	14	9.30 a.m.		30 miles from st. 54		0	6 .40			
57	14	11 a.m.		45 miles from st. 54		0	6 .00			
				64°38′						
58	14	12.30 p.m.		2°33′ W.		0	5 .20	19.50	35.25	34.36
						10	5 .40	19.80	35.79	34.88
						20	5 .20	19.80	35.79	34.88
						40	4 .20	19.80	35.79	34.88
						60	4°.40	19.80	35.79	34.88
						80	4 .30	19.88	35.93	35.01
						100	3 .60	19.88	35.93	35.01
						150	3 .00	19 88	35.93	35.01
						200	2 .60	19.88	35.93	35.01
59	14	2.40 p.m.		15 miles from st. 58		0	5 .30			
60	14	4.30 p.m.		30 miles from st. 58		0	5 .20			
61	14	7 p.m.		45 miles from st. 58		0	5 .00			
				65°16′						
62	14	9.30 p.m.		3°28′		0	5 .00	19.80	35.79	34.88
						10	4 .90	19.80	35.79	34.88
						20	4 .80	19.80	35.79	34.88
						40	4 .20	19.80	35.79	34.88
						60	3 .80	19.80	35.79	34.88
						80	3 .60	19.88	35.93	35.01
						100	3 .10	19.88	35.93	35.01
						150	2 .80	19.88	35.93	35.01
63	15	12.50 a.m.		15 miles from st. 62		0	4 .90			
64	15	2.45 a.m.		30 miles from st. 62		0	4 .40			
65	15	5 a.m.		45 miles from st. 62		0	4 .10			
66	15	6.30 a.m.				0	3 .20	19.80	35.79	34.88
						10	3 .00	19.80	35.79	34.88
						20	3 .20	19.80	35.79	34.88
						40	2 .20	19.80	35.79	34.88
						60	2 .10	19.80	35.79	34.88
						80	1 .80	19.80	35.79	34.88
						100	1 .80	19.80	35.79	34.88
						150	2 .20	19.88	35.93	35.01
						200	2 .40	19.88	35.93	35.01
						300	1 .70	19.88	35.93	35.01
67	15	9.30 a.m.		15 miles from st. 66		0	4 .40			
68	15	11 a.m.		30 miles from st. 66		0	4 .50			
69	15	12.30 p.m.		45 miles from st. 66		0	4 .60			
				66°32′						
70	15	2 p.m.		7°15′		0	2 .80	19.74	35.69	34.80
						10	2 .00	19.74	35.69	34.80
						20	1 .90	19.74	35.69	34.80
						40	2 .20	19.80	35.79	34.88
						60	2 .20	19.80	35.79	34.88
						80	2 .10	19.80	35.79	34.88
						100	2 .00	19.80	35.79	34.88
						150	1 .80	19.80	35.79	34.88
						200	2 .20	19.80	35.79	34.88
						300	1 .90	19.80	35.79	34.88
				66°38′						
71	16	3 p.m.		7°58′		0	2 .10	19.50	35.25	34.36
						10	0 .80	19.56	35.35	34.47
						20	0 .20	19.62	35.47	34.56
						40	0 .10	19.74	35.69	34.80
						60	—0 .40	19.74	35 69	34.80
						80	—0 .20	19.74	35.69	34.80
						100	0 .60	19.80	35.79	34.88
						150	0 .00	19.80	35.79	34.88
						200	0 .40	19.80	35.79	34.88
						300	0 .40	19.80	35.79	34.88
				67°26′						
72	18	7.30 a.m.		8°17′		0	0 .90	18.50	35.25	34.36
						10	0 .70	18.56	35.35	34.47
						20	0 .80	18.56	35.35	34.47
						40	—1 .20	18.62	35.47	34.56
						60	—0 .90	18.68	35.58	34.68
						80	—0 .20	18.68	35.58	34.68
						100	—0 .10	18.74	35.69	34.78
						150	0 .40	18.80	35.79	34.88
						200	0 .80	18.80	35.79	34.88
						300	0 .20	18.80	35.79	34.88

IV. Observations June 1896,

H. M. S. "Hansteen".

a) Section off Bremanger.

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	June			61°43′		Meter				
73	11	7.15 p.m.		4°21′		0	8°.20	19.63	35.51	34.61
						10	8 .15	19.63	35.51	34.61
						20	8 .07	19.63	35.51	34.61
						40	7 .65	19.97	36.08	35.16
						60	7 .75	19.97	36.08	35.16
						80	7 .65	20.00	36.14	35.21
						100	7 .70	20.02	36.16	35.25
						150	7 .25	20 02	36.16	35.25
						200	6 .80	20.02	36.16	35.25
				61°43′						
74	12	12.25 a.m.		3°30′		0	8 .10	19.39	35.04	34.18
						20	7 .90	19.39	35.04	34.18
						40	8 .50	19.97	36.08	35.16
						60	8 .40	19.99	36.15	35.20
						80	8 .22	19.99	36.15	35.20
						100	8 .15			
						150	7 .80			
						180	7 .30			
						200	6 .90			
						225	6 .75			
						250	6 .90			
						300	6 .70			
						360	6 .50	19.99	36.15	35.20
				61°43′						
75	12			2°40′		0	8 .50	19.21	34.73	33.87
						20	8 .80	19.33	34.94	34.07
						40	9 .35	19.99	36.15	35.20
						60	9 .00			
						80	8 .92			
						100	8 .60			
						150	8 .25			
						200	7 .80			
						250	7 .50			
						300	7 .20			
						350	6 .55	19.99	36.15	35.20
						400	5 .55	19.93	36.03	35.10
				61°47′						
76	12			6°46′		0	9 .80	19.81	35.80	34.89
						20	9 .60	19.81	35.80	34.89
						40	9 .40	19.93	36.03	35.10
						60	9 .40	19.99	36.15	35.20
						80	9 .35	19.99	36.15	35.20
						100	9 .20	19.99	36.15	35.20
						150	8 .80	20.05	36.21	35.30
						200	8 .45	20.05	36.21	35.30
						250	8 .20	20.05	36.21	35.30
						300	7 .50	20.05	36.21	35.30
						325	6 .30	20.05	36.21	35.30
						340	5 .55	20.05	36.21	35.30

b) Section Hustadviken—Storeggen.

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
				64° 4′.5						
77	13			5°26′		0	8°.90	19.00	34.36	33.51
						20	8 .93	19.07	34.48	33.64
						40	8 .82	19.67	35.56	34.66
						60	8 .72	19.93	36.03	35.11
						80	8 .33	19.92	36.01	35.09
						100	8 .15	19.92	36.01	35.09
						150	7 .85	19.93	36.03	35.11
						200	7 .12	19.99	36.15	35.20
						250	7 .25	19.94	36.04	35.12
						300	7 .25	19.94	36.04	35.12
						400	6 .05	19.92	36.01	35.09
						500	4 .75			
						550	2 .85	19.76	35.77	34.80
						600	0 .75	19.74	35.69	34.77
						700	— 0 .55	19.73	35.66	34.75
						800	— 0 .95	19.70	35.61	34.69
						900	— 1 .05	19.67	35.56	34.66
				63°54′						
78	13			5°57′		0	9 .08	19.29	34.88	34.01
						20	8 .45	19.41	35.08	34.21
						40	7 .72	19.83	35.85	34.93

b) Section Hustadviken—Storeggen (continued).

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
						Meter				
						60	8°.02	19.93	36.03	35.11
						80	7 .95	20.01	36.16	35.23
						100	7 .96	20.01	36.16	35.23
						150	7 .85	20.01	36.16	35.23
						200	7 .51	20.01	36.16	35.23
						250	7 .22	20.01	36.16	35.23
						290	7 .17	20.01	36.16	35.23
				63°30′						
79	13			6°17′		0	9 .01	19.06	34.46	33.63
						20	7 .32	19.29	34.88	34.01
						40	7 .32	19.71	35.62	34.71
						60	7 .20	19.95	36.05	35.13
						80	7 .52	20.01	36.16	35.23
						100	7 .80			
						150	7 .71			
						218	7 .50			
						245	7 .42	20.01	36.16	35.23
				63° 9′						
80	14			6°38′		0	9 .30	19.06	34.46	33.63
						20	7 .20	19.29	34.88	34.01
						40	6 .92	19.47	39.19	34.32
						60	7 .23	19.89	35.96	35.04
						80	7 .69	20.01	36.16	35.23
						100	7 .60	20.01	36.16	35.23
						115	7 .55	20.01	36.16	35.23

c) Section off Fröien.

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
				63°29′.8						
81	17	4¾ p.m.		10°18′.8		0	11 .19			
						20	6 .91	19.17	34 67	33.81
						40	6 .90	19.23	34.76	33.89
						60	7 .05	19.65	35.53	34.63
						80	7 .15	19.65	35.53	34.63
						100	7 .15	19.71	35.62	34.71
						150	7 .15	19.77	35.72	34.81
						180	7 .10	19.77	35.72	34.81
						200	7 .21	19.77	35.72	34.81
						250	7 .22	19.89	35.96	35.04
						300	7 .25	19.89	35.96	35.04
						320	7 .15			
						330	7 .20			
						440	7 .20	19.89	35.96	35.04
				63°32′.2						
82	17			10°23′.7		0	19 .32			
						20	7 .10	18.81	34.01	33.18
						40	7 .01	19.35	34.98	34.12
						60	7 .01	19.52	35.29	34.40
						80	7 .08	19.71	35.62	34.71
						100	7 .25	19.77	35.72	34.81
						150	7 .20	19.77	35.72	34.81
						200	7 .25	19.83	35.85	34.93
						250	7 .31	19.83	35.85	34.93
						280	7 .30	19.89	35.96	35 04
						330	7 .51	19.89	35.96	35.04
				63°40′.5						
83	17			9°44′.2		0	14 .30			
						15	7 .10	18.76	33.93	33.11
						30	6 .88	19.29	34.88	34.01
						50	6 .83	19.59	35.42	34.53
						80	7 .05	19.71	35.62	34.71
						100	7 .08	19.77	35.72	34.81
						150	7 .15	19.77	35.72	34.81
						200	7 .15	19.77	35.72	34.81
						300	7 .25	19 89	35.96	35.04

d) Section off Halten beacon.

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
				64° 5′.5						
84	19			8°15′.5		0	12°.00	18.99	34.34	33.48
						20	7 .92	19.29	34.88	34.01
						40	7 .55	19.65	35.53	34.63
						60	7 .32	19 77	35.72	34.81
						80	7 .10	19.93	36.03	35.10

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
d) Section off Halten beacon (continued).										
	June					Meter				
						100	7°.02	19.95	36.05	35.13
						150	7 .42	20.01	36.16	35.23
						200	7 .12	20.01		
						250	7 .52			
						300	7 .05			
						380	7 .05	20.01	36.16	35.23
				64°27′						
85	19	10.33 p.m.		7°57′.5		0	10 .75			
						20	8 .42	19.53	35.30	34.40
						40	7 .62	19.89	35.96	35.04
						60	7 .25	19.89		
						80	7 .00	19.89		
						100	6 .98	19.89	35.96	35.04
						150	7 .05	20.01	36.16	35.23
						220	7 .00	20.01	36.16	35.23
e) Section out off Sognefjord.										
				61°14′						
86				3° 6′		0	12°.08			
						20	12 .03	19.91	35.99	35.07

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
e) Section out off Sognefjord (continued).										
	June					Meter				
						40	10°.18	20.01	36.16	35.23
						60	9 .30	19.91	36.15	35.20
						80	9 .14	20.11	36.29	35.40
						100	8 .70	20.02	36.16	35.25
						150	8 .30	19.98	36.10	35.19
						200	7 .85	19.99	36.15	35.20
						250	7 .48	19.94	36.04	35.12
						300	6 .72	19.91	35.99	35.07
						370	6 .40	19.94	36.04	35.12
				61°14′						
87				3 43 .5		0	13 .20	19.34	34.96	34.16
						20	12 .26	19.94	36.04	35.12
						40	10 .02	20.11	36.29	35.40
						60	9 .72	20.04	36.19	35.28
						80	9 .45	20.08	36.24	35.33
						100	9 .20	20.06	36.22	35.31
						150	8 .73	20.08	36.24	35.33
						200	8 .15	20.02	36.16	35.25
						250	7 .60	19.98	36.10	35.19
						300	8 .10	19.99	36.15	35.20
						330	7 .90	20.03	36.17	35.26
						365	6 .50	19.88	35.93	35.01

V. Section Sognefjord—Iceland May 1897,

H. M. S. "Heimdal".

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
a) Section Sognefjord—Iceland.										
	May			60°47′						
88	11	9 p.m.		4°34′		0	5°.50	18.19	32.90	32.11
						10	5 .30	18.31	33.12	32.33
						20	5 .60	18.34	33.16	32.37
						50	5 .60	18.74	33.88	33.06
						80	4 .60	19.34	34.96	34.10
						120	6 .00	19.61	35.44	34.54
						200	6 .20	19.61	35.44	34.54
				61° 7′						
89	12	2½ a.m.		3°54′		0	5 .20	18.42	33.31	32.54
						10	5 .10	18.46	33.38	32.59
						20	5 .50	19.34	34.96	34.10
						50	6 .00	19.74	35.69	34.78
						80	5 .20			
						120	7 .50	19 89	35.96	35.04
						200	7 .40	19.90	35.98	35.05
				61°30·						
90	12	8 a.m.		3°13′		0	5 .40	19.21	34.74	33.87
						10	5 .30	19.21	34.74	33.87
						20	5 .50	19.42	35.10	34.23
						50	5 .80	19.46	35.16	34.30
						80	5 .90	19.57	35.38	34.50
						120	6 .00	19.73	35.66	34.75
				61°53′						
91	12	2 p.m.		2°28′		0	6 .40	19.53	35.30	34.40
						10	6 .50	19.57	35.38	34.50
						20	6 .50	19.57	35.38	34.50
						50	7 .50	19.89	35.96	35.04
						100	7 .70	19.91	35.99	35.07
92	12	7½ p.m.				0	7 .80	19.93	36.03	35.10
				62°40′						
93	13	12½ a.m.		1°20′		0	6 .50	19.89	35.96	35.04
						10	6 .40	19.89	35.96	35.04
						20	6 .20	19.89	35.96	35.04
						50	6 .30	19.89	35.96	35 04
						100	6 .50	19.89	35.96	35.04
94	13	4½ a.m.				0	7 .20	19.89	35.96	35.04
				63°26′						
95	13	7½ a.m.		0°31′ W.		0	5 .00	19.77	35.72	34.81
						10	5 .50	19.81	35.80	34.89
						20	5 .20	19.81	35.80	34.89
						50	5 .00	19 80	35.79	34.88
						80	5 .20	19.85	35.88	34.96
						120	5 .20	19.85	35.88	34.96
						200	5 .30	19.85	35.88	34.96
						300	5 .00	19.81	35.80	34.89

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
a) Section Sognefjord—Iceland (continued).										
	May									
96	13	12½ p.m.				0	4°.50	19.70	35.61	34.69
				64° 7′						
97	13	4 p.m.		2°12′ W.		0	4 .00	19.68	35.58	34.68
						10	4 .00	19.68	35.58	34.68
						20	3 .50	19.70	35.61	34.69
						50	3 .40	19.68	35.58	34.68
						80	3 .30	19.68	35.58	34.68
						120	3 .30	19.68	35.58	34.68
						200	3 .20	19.68	35.58	34.68
						300	3 .40	19.70	35.61	34.69
98	13	8½ p.m.				0	3 .30			
				64°48′						
99	14	12 a.m.		3°45′ W.		0	3 .40	19 68	35.58	34.68
						10	3 .40	19.70	35.61	34.69
						20	3 .40	19.70	35.61	34.69
						50	3 .00	19.85	35.88	34.96
						80	3 .00	19.81	35.80	34.89
						120	3 .00	19.74	35.69	34.77
						200	2 .00	19.77	35.72	34.81
						300	1 .80	19.74	35.69	34.77
100	14	4 a.m.				0	3 .50	19.74	35.69	34.77
				65°33′						
101	14	8½ a.m.		5°10′ W.		0	2 .20	19.70	35.61	34.69
						10	2 .20	19.68	35.58	34.68
						20	2 .00	19.68	35.58	34.68
						50	1 .80	19.68	35 58	34.68
						80	1 .80	19.68	35.58	34.68
						120	1 .60	19.68	35.58	34.68
						200	1 .80	19.68	35.58	34 68
						300	1 .90	19.68	35.58	34.68
102	14	1 p.m.				0	2 .50	19.63	35.51	34.61
				66°24′						
103	14	7 p.m.		7°13′ W.		0	1 .50	19.59	35.42	34.59
						10	1 .00	19.59	35.42	34.59
						20	0 .60	19.59	35.42	34.59
						50	0 .60	19.55	35.32	35.42
						80	1 .00			
						120	1 .20	19.63	35.51	34.62
						200	1 .20	19.63	35.51	34.62
						300	0 .80	19.63	35.51	34.62
104	14	11¾ p.m.				0	0 .20	19.59	35.42	34.59

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
a) Section Sognefjord—Iceland (continued).										
	May			67° 5′		Meter				
105	15	3 a.m.		8°55′ W.		0	0°.20	19.55	35.32	34.42
						10	0 .20	19.55	35.32	34.42
						20	0 .20	19.55	35.32	34.42
						50	0 .00	19.55	35.32	34.42
						80	0 .00	19.55	35.32	34.42
						120	0 .20	19.72	35.65	34.76
						200	0 .30	19.70	35.61	34.69
						300	0 .30	19.70	35.61	34.69
106	15	8 a.m.				0	—0 .50	19.48	35.21	34.33
				67°29′						
107	16	12 m.d.		10°15′ W.		0	—0 .04	19.50	35.25	34.36
				67°36′						
108	17	12 m.d.		10°38′ W.		0	—0 .20	19.50	35.25	34.36
				67°30′						
109	18	12 m.d.		10°23′ W.		0	—0 .30	19.52	35.29	34.40
						10	—0 .40	19.48	35.21	34.33
						20	—0 .40	19.48	35.21	34.33
						50	—0 .50	19.48	35.21	34.33
						80	—0 .70	19.48	35.21	34.33
						120	—0 .60	19.48	35.21	34.33
						200	0 .50	19.50	35.25	34.36
						300	0 .40	19.50	35.25	34.36
				67°37′						
110	19	12 m.d.		11°17′ W.		0	—0 .20	19.48	35.21	34.33
				67°38′						
111	20	12 m.d.		10°58′		0	0 .40	19.52	35.29	34.40
				67°23′						
112	21	12 m.d.		11°27′ W.		0	0 .80	19.70	35.61	34.69
						10	0 .50	19.59	35.42	34.53
						20	0°.50	19.59	35.42	34.53
						50	0 .00	19.59	35.42	34.53
						80	— 0 .30	19.59	35.42	34.53
						120	0 .10	19.59	35.42	34.53
						200	0 .00	19.59	35.42	34.53
						300	— 0 .40	19.59	35.42	34.53
b) Iceland—Feie beacon, surface observations.										
				67° 0′						
113	22	12 m.d.		10° 5′ W.		0	2°.00			
114	22	2 p.m.				0	1 .40	19.48	35.21	34.33
115	22	4 p.m.				0	1 .70	19.48	35.21	34.33
116	22	7 p.m.				0	1 .50	19.48	35.21	34.33
117	22	10 p.m.				0	0 .30	19.41	35.08	34.21
118	23	1 a.m.				0	0 .50	19.41	35.08	34.21
119	23	3 a.m.				0	1 .50	19.50	35.25	34.36
120	23	5 a.m.				0	2 .50	19.59	35.42	34.53
121	23	7 a.m.				0	3 .00	19.68	35.58	34.68
122	23	9 a.m.				0	3 .80	19.68	35.58	34.68
123	23	11 a.m.				0	4 .00	19.64	35.52	34.62
124	23	1 p.m.				0	5 .00	19.68	35.58	34.68
125	23	3 p.m.				0	5 .20	19.72	35.65	34.76
126	23	5 p.m.				0	5 .40	19.72	35.65	34.76
127	23	7 p.m.				0	5 .50	19.68	35.58	34.68
128	23	9 p.m.				0	6 .00	19.72	35.65	34.76
129	23	11 p.m.				0	7 .00	19.85	35.88	34.96
130	24	1 a.m.				0	7 .40	19.92	36.01	35.09
131	24	3 a.m.				0	6 .20	19.92	36.01	35.09
132	24	5 a.m.				0	7 .50	19.99	36.15	35.20
133	24	7 a.m.				0	6 .70	19.12	35.57	33.71
134	24	9 a.m.				0	7 .20	19.56	35.35	34.47
135	24	11 a.m.				0	6 .50	18.61	33.66	32.81
136	24	1 p.m.				0	6 .20	18.79	33.98	33.16
137	24	3 p.m.				0	6 .50	18.79	33.98	33.16
138	24	5 p.m.				0	7 .00	18.47	33.40	32.61

St. 113—127. Between each observation a distance of 21—22 miles.

St. 128—138. Between the observations a distance of 24 miles.

VI. Surface observations May and September 1896,

made by Capt. H. Andresen, Tromsö.[1])

No.	1896 Date	1896 Hour	Locality	Depth from which sample obtained	Temperature of the water at that depth	Cl. per litre	Salt per litre	Salt per mille
	May							
139	14	8 p.m.	Kvalsund	0	4°.20	19.19	34.72	33.86
140	14	12 midn.	4 miles W off S. Fuglö	0	4 .20	19.26	34.84	33.98
141	15	4 a.m.	10 miles WNW off S. Fuglö	0	5 .40	19.57	35.39	34.50
142	15	6 a.m.	14 miles WNW off S. Fuglö	0	5 .60	19.70	35.62	34.72
143	15	9 a.m.	18 miles WNW off S. Fuglö	0	5 .80	19.81	35.82	34 91
144	15	12 noon	23 miles NW off S. Fuglö	0	5 .60	19.81	35.82	34.91
145	15	4 p.m.	30 miles NW off S. Fuglö	0	5 .50	19.81	35.82	34.91
146	15	8 p.m.	36 miles NW off S. Fuglö	0	5 .40	19.81	35.82	34.91
147	15	12 midn.	41 miles NW off S. Fuglö	0	5 .40	19.81	35.82	34.91
148	16	4 a.m.	46 miles NW off S. Fuglö	0	4 .40			
149	16	8 a.m.	50 miles NW off S. Fuglö	0	4 .40	19.81	35.82	
150	16	4 p.m.	54 miles NW off S. Fuglö	0	3°.40	19.64	35.52	34.62
151	16	12 midn.	60 miles NW off S. Fuglö	0	0 .00	19.36	35.02	34.14
152	17	4 a.m.	64 miles NW off S. Fuglö	0	—0 .40	19.29	34.90	34.03
153	17		77°43′ N. 4°30′ E.	0		19.43	35.14	34.26
	Sept.							
154	11	11 a.m.	12 miles W off S. Cape (Spitzbergen)	0	2 .60	18.92	34.23	33.39
155	11	4 p.m.	16 miles WSW off S. Cape	0	5 .20	19.64	35.52	34.62
156	11	8 p.m.	19 miles SWtW off S. Cape	0	5 .20	19.67	35.57	34.67
157	12	4 a.m.	22 miles SW off S. Cape	0	4 .80	19.50	35.27	34.39
158	12	8 a.m.	26 miles SWtS off S. Cape	0	5 .00	19.64	35.52	34.62
159	12	10 a.m.	29 miles SWtS off S. Cape	0	5 .60	19.74	35.70	34.79

[1]) Distances in geografical miles.

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	Sept.					Meter				
160	12	12 noon		30 miles SSW off S. Cape		0	5°.60	19.81	35.82	34.91
161	12	4 p.m.		16 miles WNW off B. Eiland		0	5 .80	19.81	35.82	34.91
162	12	6 p.m.		16,5 miles W1N off B. Eiland		0	5 .80	19.81	35.82	34.91
163	12	9 p.m.		15 miles W off B. Eiland		0	5 .80	19.77	35.75	34.84
164	13	4 a.m.		17 miles WSW off B. Eiland		0	5 .80	19.57	35.39	34.50
165	13	8 a.m.		19 miles SW off B. Eiland		0	6 .20	19.74	35.70	34.79
166	13	4 p.m.		21 miles SWtS off B. Eiland		0	6 .60	19.74	35.70	34.79
167	14	4 a.m.		24 miles SWtS off B. Eiland		0	7 .60	19.77	35.75	34.84
168	14	8 a.m.		27 miles SWtS off B. Eiland		0	8 .00	19.70	35.62	34.72
169	14	4 p.m.		28 miles SSW off B. Eiland		0	8 .60	19.77	35.75	34.84
170	Sept. 15	4 a.m.		30 miles SSW off B. Eiland		Meter 0	8°.80	19.67	35.57	34.67
171	15	10 a.m.		30 miles NNW off N. Fuglö		0	9 .00	19.70	35.62	34.72
172	15	2 p.m.		25 miles NtW½W off N. Fuglö		0	9 .00	19.67	35.57	34.67
173	15	6 p.m.		22 miles NtW off N. Fuglö		0	9 .40	19.67	35.57	34.67
174	15	11 p.m.		11 miles NNW off N. Fuglö		0	8 .60	19.67	35.57	34.67
175	16	4 a.m.		15 miles NNW off N. Fuglö		0	9 .40	19.70	35.62	34.72
176	16	4 p.m.		12 miles NNW off N. Fuglö		0	10 .20	19.57	35.39	34.50
177	17	4 a.m.		4 miles NW off N. Fuglö		0	9 .80	19.67	35.57	34.67
178	17	4 p.m.		¾ miles W off S. Fuglö		0	9 .60	18.99	34.37	33.51

B. Winter time

I. Sections off the Norwegian West coast February—March 1896,

taken by O. Nordgaard.

a) Section off Stavanger.

No.	Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	Febr.			59° 3'.5						
179	7			5°32'.5		0	6°.00	18.89	34.16	33.33
						10	5 .90	18.89	34.16	33.33
						20	5 .95	19.07	34.48	33.64
						30	6 .32	19.42	35.10	34.23
						40	6 .80	19.54	35.32	34.42
						60	6 .98	19.66	35.54	34.64
						80	7 .05	19.84	35.86	34.95
						100	7 .05	19.90	35.98	35.05
						120	7 .00	19.90	35.98	35.05
				59° 6'.5						
180	7			5°18'		0	6 .00	19.05	34.44	33.63
						10	5 .90	19.05	34.44	33.63
						15	5 .80	19.35	34.98	34.13
						20	5 .80	19.35	34.98	34.13
						30	5 .95	19.47	35.19	34.32
						40	6 .00	19.50	35.25	34.36
						60	7 .02	19.77	35.72	34.81
						80	7 .12	19.77	35.72	34.81
						120	7 .22	19.83	35.85	34.93
						150	7 .12	19.95	36.05	35.13
				58°51'.5						
181	9	1½-3 p.m.		4°57'		0	5 .80	19.01	34.38	33.54
						5	5 .62	19.07	34.48	33.64
						10	5 .60	19.14	34.60	33.76
						15	5 .67	19.14	34.60	33.76
						20	5 .70			
						30	5 .85	19.31	34.91	34.04
						40	5 .88	19.36	35.00	34.13
						60	6 .40	19.54	35.32	34.42
						70	6 .70	19 54	35.32	34.42
						80	6 .90	19.66	35.54	34.64
						100	7 .20	19.84	35.86	34.95
						120	7 .15	19.90	35.98	35.05
						150	7 .10	19.90	35.98	35.05
						200	6 .50	19.96	36.07	35.15

a) Section off Stavanger (continued).

No.	Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	Febr.			58°59'						
182	9	4½-5¼ p.m.		5°21'		0	5°.80	19.19	34.69	33.84
						5	5 .71	19.19	34.69	33.81
						10	5 .71	19.19	34.69	33.84
						15	5 .71	19.19	34.69	33.84
						20	5 .81	19.31	34.91	34.01
						30	5 .90	19.36	35.00	34.13
						40	6 .50	19.60	35 42	34.53
						60	6 .95	19.78	35.75	34.83
						80	7 .21	19.90	35.98	35.05
						100	7 .20	19.90	35.98	35.05

b) Section off Marstenen beacon.

No.	Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	Febr.			60° 9'						
183	14	5—6 p.m.		5° 4'		0	4°.50	15.86	28.71	28.13
						10	6 .10	18.65	33.68	32.86
						20	6 .25	19 19	34.69	33.84
						30	6 .32	19.30	34.89	34.02
						50	6 .35	19.48	35.21	34.33
						60	6 .75	19.66	35.54	34 64
						80	7 .16	19.78	35.75	34.84
						120	7 .17	19.78	35.75	34.81
						150	7 .25	19.90	35.98	35.05
				60° 6'						
184	15	11-12 a.m.		4° 5'		0	5 .60	19.31	34.91	34.01
						10	5 .65	19.31	34.91	34.04
						20	5 .70	19.36	35.00	34.13
						30	5 .85	19.36	35.00	34.13
						40	7 .45	19.97	36.08	35.16
						50	7 .48	19.97	36.08	35.16
						60	7 .55	19.97	36.08	35.16
						80	7 .60	19.97	36.08	35.16
						120	7 .80	20.03	36.17	35.26
						200	7 .85	20.06	36.23	35.31
						250	7 .47	20.06	36.23	35.31

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
b) Section off Marstenen beacon (continued).										
	Febr.			60° 7′		Meter				
185	15	2—3 a.m.		4°38′		0	5°.62	19.36	35.00	34.13
						10	5 .70	19.36	35.00	34.13
						20	5 .85	19.36	35.00	34.13
						30	6 .15	19.42	35.10	34.23
						40	6 .20	19.42	35.10	34.23
						60	6 .45	19.54	35.32	34.42
						80	7 .17	19.78	35.75	34.84
						120	7 .35	19.90	35.98	35.05
						150	7 .20	19.96	36.07	35.15
c) Section off Christianssund.										
				63°26′		Meter				
186	22	10¼-11¼ a.m.		6°47′		0	5°.50	19.45	35.16	34.28
						10	5 .60	19.45	35.16	34.28
						20	5 .80	19.51	35.28	34.38
						30	5 .81	19.51	35.28	34.38
						40	5 .76 ?	19.51	35.28	34.38
						60	5 .87	19.60	35.42	34.53
						80	6 .15	19.63	35.51	34.61
						120	6 .55	19.69	35.60	34.70
						150	7 .07	19.80	35.79	34.88
						200	7 .15	19.83	35.85	34.93
						250	7 .10	19.94	36.04	35.12
				63°16′.5						
187	22	12½-1 a.m.		7° 8′		0	5 .60	19.38	35.03	34.16
						10	5 .65	19.38	35.03	34.16
						20	5 .57	19.41	35.08	34.21
						30	5 .60	19.45	35.16	34.28
						40	5 .61	19.45	35.16	34.28
						60	5 .77	19.51	35.28	34.38
						80	5 .85	19.51	35.28	34.38
						100	5 .85	19.51	35.28	34.38
						120	5 .83	19.51	35.28	34.38
				63°11′.5						
188	22	2½-3 p.m.		7°19′		0	4 .60	18.74	33.88	33.06
						10	4 .65	18.74	33.88	33.06
						20	5 .05	18.92	34.23	33.38
						30	5 .15	19.09	34.51	33.66
						40	5 .25	19.09	34.51	33.66
						60	5 .70	19.33	34.94	34.07
						80	5 .85	19.51	35.28	34.38
						100	5 .85	19.51	35.28	34.38
						120	5 .83	19.57	35.38	34.50
d) Section off Vigten.										
				64°39′		Meter				
189	28	12—1 p.m.		9°57′		0	5°.20			
						10	5 .55	19.39	35.04	34.18
						20	5 .85	19.57	35.38	34.50
						30	6 .00			
						40	6 .03			
						60	6 .15	16.69	35.60	34.70
						80	6 .25	19.75	35.71	34.80
						100	6 .55	19.75	35.71	34.80
						120	6 .65	19.81	35.80	34.89
						150	6 .80	19.87	35.91	35.00
						200	6 .95	19.92	36.01	35.09
						250	6 .83	19.98	36.10	35.19
				64°41′.5						
190	28	2½-3½ p.m.		10°27′		0	4 .40	18.86	34.10	33.26
						10	4 .65			
						20	4 .67	18.98	34.32	33.48
						30	4 .70	18.98	34.32	33.48
						40	5 .05	19.09	34.51	33.66
						50	5 .15	19.19	34.69	33.84
						60	5 .47	19.33	34.94	34.07
						70	6 .00			
						100	6 .25	19.57	35.38	34.50
						120	6 .55	19.75	35.71	34.80
						150	6 .95	19.92	36.01	35.09
				64°42′						
191	28	4½—5 p.m.		10°44′.5		0	4 .20	18.86	34.10	33.26
						10	4 .35			
						20	4 .40			
						30	4 .43	18.98	34.32	33.48
						50	4 .75	19.04	34.42	33.58

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
d) Section off Vigten (continued).										
						Meter				
						60	5°.20			
						80	5 .83	19.39	35.04	34.18
						120	6 .55	19.63	35.51	34.61
e) Section off Lofoten.										
	March			67°35′		Meter				
192	13	9—9½ a.m.		12°20′		0	3°.90	19.19	34.69	33.84
						10	3 .95	19.21	34.73	33.87
						20	4 .00	19.27	34.83	33.97
						30	4 .60	19.27	34.83	33.97
						40	4 .30	19.33	34.94	34.07
						50	4 .33	19.33	34.94	34.07
						60	4 .30	19.33	34.94	34.07
						80	4 .77	19.39	35.04	34.18
						100	5 .25	19.45	35.16	34.28
						120	5 .55	19.51	35.28	34.38
						25	4 .15	19.27	34.83	33.97
						30	4 .15	19.30	34.89	34.02
						35	4 .11	19.33	34.94	34.07
						50	4 .10	19.33	34 94	34.07
				67°47′.5						
193	13	12—1 a.m.		11°42′		0	5 .00	19.51	35.28	34.38
						10	4 .97	19.57	35.38	34.50
						20	4 .95	19.57	35.38	34.50
						30	4 .97	19.57	35.38	34.50
						40	4 .96	19.63	35.51	34.61
						50	4 .95	19.63	35.51	34.61
						60	4 .97	19.63	35.51	34.61
						80	5 .03	19.63	35.51	34.61
						100	5 50	19.69	35.60	34.70
						120	6 .16	19.81	35.80	34.89
						150	6 .55	19.92	36.01	35.09
				67°42′						
194	13	2½-3½ p.m.		12° 5′.5		0	4 .40	19.39	35.04	34.18
						10	4 .30	19.39	35.04	34.18
						20	4 .25	19.39	35.04	34.18
						30	4 .37	19.39	35.04	34.18
						40	4 .55	19.45	35.16	34.28
						50	4 .68	19.51	35.28	34.38
						60	4 .77	19.51	35.28	34.38
						80	5 .23	19.57	35.38	34.50
						100	5 .75	19.69	35.60	34.70
				67°35′						
195	13	5—5½ p.m.		12°30′		0	3 .80	19.14	34.60	33.76
						10	3 .83	19.14	34.60	33.76
						20	3 .95	19.20	34.72	33.87
						30	4 .15	19.20	34.72	33.87
						40	4 .25	19.30	34.72	33.87
						60	4 .85	19.32	34 92	34.04
						80	4 .87	19.38	35.03	34.16
						100	4 .90	19.38	35.08	34.16
				67°36′						
196	14	6½-7¾ a.m.		13° 2′		0	3 .70	19.20	34.72	33.87
						10	3 .85	19.20	34.72	33.87
						20	3 .87	19.20	34.72	33.87
						30	3 .93	19.20	34.72	33.87
						40	3 .97	19.20	34.72	33.87
						50	3 .97	19.20	34.72	33.87
						60	4 .05	19.20	34.72	33.87
						80	4 .05	19.26	34.81	33.95
						100	4 .10	19.26	34.81	33.95
						120	4 .15	19.26	34.81	33.95
				67°32′.5						
197	14	9½-10 a.m.		13°24′.5		0	3 .60	19.20	34.72	33.87
						10	3 .65	19.20	34.72	33.87
						20	3 .65	19.20	34.72	33.87
						30	3 .65	19.20	34.72	33.87
						40	3 .60	19.20	34.72	33.87
						60	3 .75	19.20	34.72	33.87
						80	4 .77	19.32	34.92	34.06
						120	5 .37	19.50	35.25	34.36
						150	6 .55	19.69	35.60	34.70
						200	6 .55	19.95	35.88	34.96

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
e) Section off Lofoten (continued).										
198	March 14	11½-12½ a.m.		67°28′.5 13°49′		Meter 0	3°.40	19.14	34.62	33.78
						10	3 .50	19.15	34.62	33.78
						20	3 .47	19.15	34.62	33.78
						30	3 .47	19.15	34.62	33.78
						40	3 .47	19.15	34.62	33.78
						60	3 .80	19.27	34.83	33.97
						80	5 .23	19.45	35.16	34.28
						120	5 .70	19.57	35.38	34.50
						150	6 .10	19.69	35.60	34.70
						200	6 .45			
						250	6 .57	19.93	36.03	35.11

II. Observations from Lofoten. March—April 1896.

taken by O. Nordgaard.

199	March 9	5½ a.m.		On Napströmmen	Meter 0	3°.00	18.78	33.98	33.15
200	9	5½ a.m.		On Napströmmen	0	3 .00	18.78	33.98	33.15
201	10	8½ a.m.		2 miles off Lofotodden	0	3 .00	18.90	34.20	33.35
202	10			Between Mosken and Lofotodden	0	3 .20	18.86	34.13	33.29
203	10			1 mile off Mosken	0	3 .60	19.03	34.44	33.58
204	10	9½ a.m.		Between Mosken and Værö	0	3 .40	18.97	34.33	33.48
205	10			At Værö	0	3 .40	18.97	34.33	33.48
The samples obtained on the line Helligvær—Svolvær.										
206	14	1 p.m.		8 miles off St. III (Helligvær)	Meter 0	3°.50	18.92	34.24	33.39
207	14	2 p.m.		17 miles off St. III (Helligvær)	0	3 .40	18.92	34.24	33.39
208	14	3 p.m.		26 miles off St. III (Helligvær)	0	3 .40	18.92	34.24	33.39
209	14	4 p.m.		34 miles off St. III (Helligvær)	0	2 .20	18.62	33.69	32.88
210	14	5 p.m.		10 miles off Svolvær	0	2 .20	18.66	33.76	32.94
211	14	5½ p.m.		6 miles off Svolvær	0	2 .10	18.55	33.56	32.75
212	17	1 p.m.		St. I 7 miles SOtS off Stamsund	0	2 .50	18.73	33.89	33.06
					10	2 .50			
					20	2 .50			
					30	2 .50			
					40	2 .50			
					60	2 .73			
					80	3 .17	18.83	34.07	33.23
					100	3 .45			
					120	3 .45	18.92	34.24	33.39
213	17			St. II 4 miles $8tO^1/_2O$ off Henningsvær	0	2 .40			
					10	2 .15			
					20	2 .15			
					30	2 .20			
					40	2 .55			
					60	2 .97			
					80	3 .60	18.96	34.31	33.46
					100	3 .95			
					120	6 .45	19.63	35.50	34.60
214	March 23			1 mile off Reine	Meter 0	2°.20	18.96	34.31	33.46
215	23	11 a.m.		St. I 8 milesSOtO off Reine	0	2 .30	18.73	33.89	33.06
					10	2 .35			
					20	3 .25	18.98	34.34	33 50
					30	3 .25			
					40	3 .27			
					50	3 .65	19.03	34.44	33.58
					60	3 .67			
					80	4 .05	19.11	34.58	33.72
					100	4 .83	19.26	34.85	33.98
					120	6 .02	19.50	35.27	34.38
					150	6 .53	19.65	35.55	34.65
216	23	2 p.m.		St. II 16 miles SOtS off Reine	0	3 .20	18.96	34.31	33.46
					10	3 .25			
					20	3 .25			
					30	3 .25			
					40	3 .25			
					50	3 .30	19.03	34.44	33.58
					80	3 .57	19.07	34.51	33.65
					100	4 .03			
					120	4 .40	19.13	34.61	33.75
					150	5 .45	19.37	35.02	34.17
					200	6 .55	19.71	35.65	34.75
217	23	5 p.m.		St. III 5 miles SOtO off Reine	0	2 .80	18.78	33.98	33.15
					10	3 .20			
					20	3 .70	18.96	34.31	33.46
					30	3 .87	19.00	34.38	33.52
					50	4 .15			
					60	4 .43			
					80	5 .25	19.30	34.91	34.02
					100	5 .83			
218	26	11 a.m.		St. I 5 miles SOtO off Reine	0	2 .50	18.60	33.65	32.83
					10	2 .50			
					20	2 .97	18.70	33.84	33.01
					30	3 .25			
					40	3 .40			
					45	2 .55	18.60	33.65	32.83
					50	2 .50	18.60	33.65	32.83
					55	3 .45	18.93	34.25	33.40
					60	3 .45	18.98	34.25	33.40
					70	3 .65			
					80	3 .85			
219	26	3½ p.m.		St. II 10 miles SOtO off Reine	0	3 .60	18.83	34.07	33.23
					10	3 .55			
					20	2 .94	18.87	34.16	33.30
					25	3 .45			
					30	3 .55			
					40	3 .63			
					60	3 .75			
					80	3 .95	19.03	34.44	33.58
					100	4 .45			
					120	5 .75			
					150	6 .45			
220	26	5 p.m.		St. III 8 miles SOtO off Reine	0	3 .20	18.78	33.98	33.15
					10	3 .20			
					20	3 .25	18.87	34.16	33.30
					30	3 .45			
					40	3 .45			
					60	3 .83			
					80	3 .78?	19.03	34.44	33.58
					100	4 .65	19.18	34.70	33.84

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	April				Meter	Meter				
221	9	3 p.m.		St. I		0	2°.20	18.66	33.76	32.94
				1 mile off		10	2 .45	18.73	33.89	33.06
				Skraaven		20	2 .70	18.87	34.16	33.30
						30	3 .05	18.90	34.20	33.35
						40	3 .17	18.96	34.31	33.46
						100	3 .80	19.12	34.60	33.73
						150	6 .30	19.59	35.43	34.54
222	9			St. II		0	1 .80	18.25	33.02	32.24
				Höla		10	2 .05	18.46	33.40	32.60
						20	3 .67	18.85	34.12	33.27
						30	3 .70	18.92	34.24	33.39
						40	3 .93	18.98	34.34	33.50
						100	4 .95	19.23	34.85	33.98
						150	5 .93	19.44	35.17	34.29
223	13	9 a.m.		St. I	70	0	2 .80	18.73	33.88	33.06
				$3^1/_2$ miles		10	2 .80			
				ONO off		20	2 .80	18.75	33.94	33.10
				Nufsfjord		30	3 .05	18.81	34.03	33.20
						40	3 .10	18.87	34.16	33.30
						60	3 .35	18.97	34.33	33.48
						70	3 .80	19.03	34.44	33.58
224	13	$2^1/_2$ p.m.		St. II	80	0	3 .40	18.70	33.84	33.01
				2 miles		10	3 .05	18.73	33.88	33.06
				SV off		20	2 .97	18.76	33.94	33.11
				Nufsfjord		30	2 .95	18.76	33.94	33.11
						40	3 .17	18.86	34.13	33.29
						60	3 .75	18.98	34.34	33.50
						80	4 .00	19.03	34.44	33.58

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	April					Meter				
225	15	12 noon		St. I		0	3°.10	18.86	34.13	33.29
				7 miles		10	3 .20	18.86	34.13	33.29
				SSO off		20	3 .20	18.86	34,13	33.29
				Balstad		40	3 .30	18.92	34.24	33.39
						60	3 .90	19.10	34.56	33.70
						80	3 .95	19.10	34.56	33.70
						120	4 .40	19.15	34.66	33.79
226	15	2 p.m.		St. II		0	3 .30	18.90	34.20	33.35
				4 miles		10	3 .30	18.90	34.20	33.35
				St O $^1/_2$ O		20	3 .25	18.90	34.20	33.35
				off Balstad		30	3 .25	18.90	34.20	33.35
						40	3 .27	18.97	34.33	33.48
						60	3 .35	18.97	34.33	33.48
						80	3 .95	19.10	34.56	33.70
						100	4 .73	19.24	34.81	33.94
227	15	10 a.m.		At		0	3 .00	18.60	33.65	32.83
				Svinöen						
				(Balstad)						
228	15	11 a.m.		5 miles		0	3 .00	18.71	33.87	33.03
				St. W off						
				Svinöen						

III. Observations March—April 1897,

made by Capt. Bie.

a) Utsire—Iceland.

No.	Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	March					Meter				
229	4	11 a.m.		59° 2′		0	6°.30	19.86	35.89	34.97
				3°58′		10	6 .40	19.94	36.04	35.12
						20	6 .35	19.82	35.85	34.92
						50	6 .30	19.82	35.85	34.92
						80	6 .45	19.94	36.04	35.12
						120	6 .50	19.94	36.04	35.12
						200	6 .80	19.91	35.99	35.07
						300	6 .75	19.96	36.07	35.15
230	4	4 p.m.		59°26′		0	5 .85	19.90	35.98	35.05
				3°13′		10	5 .80	20.02	36.16	35.25
						20	5 .85	19.98	36.10	35.19
						50	5 .90	19.90	35.98	35.05
						80	5 .85	19.92	36.01	35.09
						120	5 .85	19.94	36.04	35.12
231	4	9 p.m.		59°45′		0	6 .30	19.98	36.10	35.19
				2°30′		10	6 .20	19.98	36.10	35.19
						20	6 .15	19.98	36.10	35.19
						50	6 .30	19.95	36.05	35.15
						80	6 .40	19.94	36.04	35.12
						120	6 .30	19.92	36.01	35.09
232	5	3 a.m.		30 miles from St. 231		0	6 .20	19.98	36.10	35.19
233	5	8 a.m.		60°44′ 0°24′		0	7 .40	20.01	36.16	35.23
234	5	11 a.m.		61° 8′		0	7 .40	20.02	36.16	35.25
				0°20′ W.		10	7 .50	20.02	36.16	35.25
						20	7 .45			
						50	6 .40	19.91	35.99	35.07
						80	6 .40	19.94	36.04	35.12
						140	6 .20	20.00	36.14	35.21
235	5	7 p.m.		30 miles from St. 234		0	7 .80	20.05		
236	6	$12^1/_2$ a.m.		61°43′ 2°18′ W.		0	5 .30	19.78	35.78	34.86
237	6	$4^1/_2$ a.m.		30 miles from St. 237		0	3 .00	19.69	35.60	34.70

a) Utsire—Iceland (continued).

No.	Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	March					Meter				
238	6	$8^1/_2$ a.m.		62° 1′		0	4°.10	19.37	35.66	34.75
				3°50′ W.		10	4 .20	19.69	35.60	34.70
						20	4 .20	19.68	35.58	34.68
						50	4 .40	19.69	35.60	34.70
						80	5 .20	19.77	35.72	34.81
						120	5 .20	19.78	35.75	34.84
						200	5 .40	19.80	35.79	34.88
						300	5 .80	19.86	35.89	34.97
						500	0 .80	19.86	35.89	34.97
239	6	3 p.m.		30 miles from St. 238		0	6 .50	19.94	36.04	35.12
240	6	8 p.m.		62°35′ 5°44′ W.		0	6 .50	19.90	35.98	35.05
						10	6 .60	19.90	35.98	35.05
						20	6 .50	19.90	35.98	35.05
						50	6 .30	19.90	35.98	35.05
						80	6 .40	19.86	35.89	34.97
						140	6 .30	19.88	35.93	35.01
241	7	1 a.m.		30 miles from St. 240		0	7 .00	19.96	36.07	35.15
242	7	8 a.m.		63° 5′ 8° 9′ W.		0	7 .10	19.92	36.01	35.09
						10	6 .80	19.90	35.98	35.05
						20	6 .90	19.93	36.03	35.11
						50	6 .85	19.93	36.03	35.11
						80	6 .70	19.98	36.10	35.19
						120	6 .80	19.92	36.01	35.09
						200	6 .30	19.89	35.96	35.04
						300	5 .80	19.89	35.96	35.04
243	7	$12^1/_2$ p.m.		30 miles from St. 242		0	6 .80	19.90	35.98	35.05
244	7	$5^1/_2$ p.m.		63°15′ 10°56′ W.		0	2 .60	19.62	35.47	34 56
						10	2 .90	19.62	35.47	34.56
						20	2 .90	19.62	35.47	34 56
						50	3 .50	19.64	35.52	34.62
						80	4 .50	19.70	35.61	34.69
						120	5 .00	19.73	35.66	34.75
						200	4 .20	19.73	35.66	34.75
245	7	11 p.m.		30 miles from St. 244		0	6 .40	19.87	35.91	35.00
246	8	4 a.m.		63°14′ 13°22, W.		0	7 .20	19.92	36.01	35.09

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
a) Utsire—Iceland (continued).										
	March					Meter				
247	8	8 a.m.		30 miles from St. 246		0	7°.80	19.98	36.10	35.19
248	8	12 noon		63°27′ 14°59′ W.		0	7 .85	19.95	36.05	35.13
249	8	4 p.m.		30 miles from St. 248		0	7 .20	19.94	36.04	35.12
250	8	8 p.m.		63°16′ 17°15′ W.		0	6 .80	19.93	36.03	35.11
251	9	4 a.m.		30 miles from St. 250		0	7 .20	19.93	36.03	35.11
252	9	10 a.m.		63°10′ 19° 5′ W.		0	7 .20	19.89	35.96	35.04
253	9	1¼ p.m.		63°28′.5 20° 3′		0	7 .25	19.95	36.05	35.13
254	9	7¼ p.m.		30 miles from St. 253		0	6 .50	19.94	36.04	35.12
255	10	8¼ a.m.		63°35′ 22°17′ W.		0	6 .40	19.97	36.08	35.16
256	10	2 p.m.		30 miles from St. 255		0	5 .40	19.73	35.66	34.75
257	10	6 p.m.		64°20′ 24° 0′ W.		0	6 .00	19.97	36.08	35.16
258	10	10 p.m.		30 miles from St. 257		0	5 .70	19.93	36.03	35.11
259	11	2¼ a.m.		65°18′ 24°50′		0	2 .50	19.50	35.25	34.36
260	11	6¼ a.m.		30 miles from St. 259		0	0 .70	19.30	34.89	34.02
261	11	1 p.m.		66°11′ 23°44′ W.		0	0 .60	19.54	35.32	34.42
b) Iceland (Meleyre).										
						Meter				
262	15			66°22′ 22°14′ W.		0	0°.50	19.39	35.04	34.18
	19					0	— 0 .10	19.46	35.16	34.30
	23					0	— 0 .25	19.31	34.91	34.04
						5	0 .20	19.35	34.98	34.12
						10	0 .20	19.41	35.08	34.21
	27					0	— 0 .20	19 38	35.03	34.16
	31					0	— 0 .90	19.40	35.06	34.20
	April 4					0	0 .30	19.37	35.01	34.14
c) Iceland—Hammerfest.										
						Meter				
263	8	12 noon		66°24′ 23°19′ W.		0	1°.50	19.61	35.45	34.54
264	8	4½ p.m.		30 miles from St. 263		0	1 .00	19.62	35.47	34.56
265	8	9 p.m.		66°31′ 21° 5′ W.		0	0 .60	19.64	35.52	34.62
266	9	1 a.m.		30 miles from St. 265		0	1 .80	19.64	35.52	34.62
267	9	5½ a.m.		66°23′ 18°31′ W.		0	1 .80	19.65	35.53	34.63
c) Iceland—Hammerfest (continued).										
	April					Meter				
268	9	9 a.m.		30 miles from St. 267		0	1°.80	19.62	35.47	34.56
269	9	1 p.m.		66°49′ 16° 5′ W.		0	1 .90	19.68	35.58	34.68
270	9	5 p.m.		30 miles from St. 269		0	1 .50	19.53	35.30	34.40
271	9	7 p.m.		67° 7′ 14°20′ W.	190	0	1 .60	19.59	35.42	34.53
						10	1 .80	19.59	35.42	34 53
						20	1 .70	19.65	35.53	34.63
						50	1 .80			
						80	1 .70	19.69	35.60	34.70
						120	1 .70	19.61	35.45	34.55
						180	1 .90	19.65	35.53	34.63
272	10	12¼ a.m.		30 miles from St. 271		0	— 1 .20	19.40	35.06	34.20
273	10	5 a.m.		67°27′ 12°10′ W.		0	— 0 .90	19.36	35.00	34.13
274	10	8 a.m.		67°24′ 10° 0′ W.		0	— 1 .20	19.34	34.96	34.10
						10	— 1 .30	19.40	35.06	34.20
						20	— 1 .40	19.40	35.06	34.20
						50	— 0 .40	19.45	35.16	34.28
						80	— 0 .10	19.49	35.23	34.34
						120	0 .00	19.63	35.51	34.61
						250	— 0 .60	19.53	35.30	34.40
275	10	1 p.m.		30 miles from St. 274		0	— 0 .60	19.40	35.06	34.20
276	10	5½ p.m.		60 miles from St. 274		0	— 1 .20	19.40	35.06	34.20
277	10	7½ p.m.		67°44′ 6°43′ W.		0	— 1 .30	19.40	35.06	34.20
						10	— 1 .10	19.34	34.96	34.10
						20	— 1 .00	19.35	34.98	34.12
						50	— 0 .90	19.57	35.38	34.50
						80	+ 0 .20	19.69	35.60	34.70
						120	0 .60	19.71	35.62	34.71
						200	0 .80	19.73	35.66	34.75
						300	1 .00	19.73	35.66	34.75
278	11	12¼ a.m.		30 miles from St. 277		0	— 1 .10	19.60	35.42	34.53
279	11	4½ a.m.		60 miles from St. 277		0	+ 0 .50	19.73	35.66	34.70
280	11	8 a.m.		67°57′ 3° 6′ W.		0	2 .70	19.82	35.85	34.92
						10	2 .80	19.82	35.85	34.92
						20	2 .80	19.82	35.85	34.92
						50	2 .85	19.82	35.85	34.92
						100	2 .95	19.82	35.85	34.92
						200	3 .00	19.86	35.89	34.97
281	11	1 p.m.		30 miles from St. 280		0	3 .20	19.92	36.01	35.09
282	11	6 p.m.		68°15′ 1°30′ W.		0	3 .10	19.94	36.04	35.12
283	11	11 p.m.		30 miles from St. 282		0	4 .50	19.92	36.01	35.09
284	12	5 a.m.		68°43′ 1° 9′ O.		0	4 .40	19.98	36.10	35.19
285	12	12¼ p.m.		30 miles from St. 284		0	5 .50	19.98	36.10	35.19
286	12	6¼ p.m.		69°22′ 3°12′		0	4 .70	19.86	35.89	34.97

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
c) Iceland—Hammerfest (continued).										
287	April 12	11¾ p.m.		30 miles from St. 286		Meter 0	4°.30	19.93	36.03	35.10
288	13	4½ a.m.		69°42, 5°49′		0	4.65	19.91	35.99	35.07
289	13	9¾ a.m.		30 miles from St. 288		0	4.90	19.89	35.96	35.04
290	13	4 p.m.		69°56′ 9°20′		0	5.40	19.90	35.98	35.05
291	13	9 p.m.		30 miles from St. 290		0	4.20	19.93	36.03	35.10
292	14	2 a.m.		70°17′ 12°20′		0	5.00	19.89	35.96	35.04
293	14	6½ a.m.		30 miles from St. 292		0	4.90	19.96	36.07	35.15
294	14	8 a.m.		70°29′ 13°56′		0	4.80	19.86	35.89	34.97
						50	4.70	19.87	35.91	35.00
						100	4.60	19.88	35.93	35.01
						200	5.00	19.86	35.89	34.97
						300	4.60	19.89	35.96	35.04
295	14	2 p.m.		30 miles from St. 294		0	5.40	19.81	35.80	34.89
296	April 14	7 p.m.		70°31′ 17° 8′		Meter 0	5°.05	19.65	35.53	34.63
						10	5.10	19.61	35.45	34.55
						20	5.00	19.67	35.56	34.66
						50	5.10	19.68	35.58	34.68
						100	5.15	19.75	35.71	34.80
						200	5.30	19.78	35.75	34.84
297	15	12¾ a.m.		30 miles from St. 296		0	4.10	19.51	35.28	34.38
298	15	5½ a.m.		70°44′ 20° 0′		0	3.90	19.55	35.32	34.45
	15	8 a.m.		70°45′ 20°30′		0	4.10	19.62	35.47	34.56
						10	4.10	19.62	35.47	34.56
						20	4.10	19.61	35.45	34.54
						50	4.00	19.61	35.45	34.54
						80	4.00	19.62	35.47	34.56
						120	4.30	19.63	35.51	34.61
299	15	12 noon		16 miles NW off Sörö		0	3.90	19.55	35.32	34.42
300	15	3½ p.m.		Between Sörö and Ingö		0		19.52	35.29	34.40
301	15	7 p.m.		Hammerfest		0	2.00	19.52	35.29	34.40

IV. Surface observations in the Norwegian Sea and in the North Sea February—March 1897.

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
a) Utsire—Arctic Ocean, S/S „Westye Egeberg", Capt. Tufte.										
302	March 5	8 a.m.		59°20′ 4 20′		Meter 0	3 °	18.81	34.01	33.19
303	5	10½ a.m.		59 35′ 4 13′		0	3¼	19.73	35.66	34.73
304	5	0½ p.m.		59 50′ 4 10′		0	5¾	19.69	35.60	34.70
305	5	2½ p.m.		60 5′ 4 5′		0	5¾	19.50	35.25	34.36
306	5	5 p.m.		60 19′ 4 0′		0	5½	19.34	34.96	34.10
307	5	8 p.m.		60 33′ 3 54′		0	5	19.26	34.81	33.95
308	5	11 p.m.		60 47′ 3 48′		0	5½	19.89	35.96	35.04
309	6	2 a.m.		61 1′ 3 44′		0	5¼	19.26	34.81	33.95
310	6	6 a.m.		61 15′ 3 40′		0	5¾	19.81	35.80	34.89
311	6	9½ a.m.		61 29′ 3 33′		0	6¼	19.73	35.66	34.73
312	6	7½ p.m.		61 44′ 3 26′		0	6	19.50	35.25	34.36
313	6	10½ p.m.		61 59′ 3 20′		0	5½	19.73	35.66	34.73
314	7	1½ a.m.		62 13′ 3 12′		0	5½	19.93	36.02	35.10
315	7	4½ a.m.		62 28′ 3 6′		0	5¼	19.93	36.02	35.10
316	7	7½ a.m.		62 43′ 3 0′		0	6¼	19.95	36.05	35.13
317	7	10½ a.m.		62 58′ 2 56′		0	6¼	19.89	35.96	35.04
318	7	1½ p.m.		63 13′ 2 52′		0	6½	19.89	35.96	35.04
319	7	4½ p.m.		63 28′ 2 48′		0	6½	19.87	35.91	35.00
320	7	12 midn.		63 43′ 2 42′		0	6½	19.86	35.89	34.97
a) Utsire—Arctic Ocean, S/S „Westye Egeberg", Capt. Tufte (continued).										
321	March 8	8 a.m.		63°58′N. 2 35′E.		Meter 0	6½°	19.87	35.91	35.00
322	8	0½ p.m.		64 8′ 2 28′		0	5	19.82	35.85	34.92
323	8	3¼ p.m.		64 23′ 2 26′		0	4½	19.85	35.88	34.96
324	8	6¼ p.m.		64 38′ 2 24′		0	4½	19.84	35.86	34.94
325	8	9 p.m.		64 53′ 2 22′		0	5	19.90	35.98	35.05
326	8	12 midn.		65 8′ 2 17′		0	5½	19.89	35.96	35.04
327	9	2¾ a.m.		65 24′ 2 12′		0	4½	19.90	35.98	35.05
328	9	5 a.m.		65 40′ 2 7′		0	6	19.89	35.96	35.04
329	9	7 a.m.		65 55′ 2 2′		0	6	19.89	35.96	35.04
330	9	9 a.m.		66 10′ 1 58′		0	5¾	19.89	35.96	35.04
331	9	11 a.m.		66 25′ 1 54′		0	5½	19.93	36.02	35.10
332	9	0¾ p.m.		66 40′ 1 50′		0	5½	19.89	35.96	35.04
333	9	2¾ p.m.		66 55′ 1 48′		0	5½	19.89	35.96	35.04
334	9	4¾ p.m.		67 10′ 1 46′		0	5½	19.89	35.96	35.04
335	9	6½ p.m.		67 25′ 1 44′		0	5½	19.91	35.99	35.07
336	9	8½ p.m.		67 40′ 1 42′		0	5½	19.89	35.96	35.04
337	9	10½ p.m.		67 55′ 1 40′		0	4½	19.85	35.88	34.96
338	10	1 a.m.		68 10′ 1 38′		0	4½	19.89	35.96	35.04
339	10	3½ a.m.		68 25′ 1 36′		0	4½	19.89	35.96	35.04

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
a) Utsire—Arctic Ocean, S S „Westye Egeberg", Capt. Tufte (continued).										
	March					Meter				
340	10	6 a.m.		68°40′ 1 33′		0	4¾	19.88	35.93	35.01
341	10	8 a.m.		68 53′ 1 30′		0	4½	20.13		
342	10	10½ a.m.		69 10′ 1 27′		0	3¾	19.85	35.88	34.96
343	10	0½ p.m.		69 25′ 1 19′		0	4	19.89	35.96	35.04
344	10	2¾ p.m.		69 40′ 1 12′		0	4¼	19.85	35.88	34.96
345	10	5½ p.m.		69 55′ 1 4′		0	4¼	19.81	35.80	34.89
346	10	7¾ p.m.		70 10′ 0 58′		0	4¼	19.81	35.80	34.89
347	10	10½ p.m.		70 25′ 0 50′		0	4¼	19.81	35.80	34.89
348	11	1 a.m.		70 40′ 0 42′		0	3¾	19.87	35.91	35.00
349	11	3¾ a.m.		70 55′ 0 34′		0	3½	19.93	36.02	35.10
350	11	6½ a.m.		71 10′ 0 24′		0	3¼	19.88	35.93	35.01
351	11	9¾ a.m.		71 24′ 0 12′ E.		0	— ½	19.81	35.80	34.89
352	11	0½ p.m.		71 38′ 0 10′ W.		0	1½			
353	11	3 p.m.		71 53′ 0 15′		0	1½	19.52	35.29	34.40
354	11	6 p.m.		72 7′ 0 30′		0	1½	19.53	35.30	34.40
355	11	11 p.m.		72 22′ 0 50′ W.		0	— 1½	19.53	35.30	34.40
b) Utsire—Arctic Ocean, Capt. O. Simonsen.										
						Meter				
356	5	12 noon		58°36′ 3 42′ E.		0	6°.00	19.85	35.88	34.96
357	5	5 p.m		59 3′ 3 14′		0	5 .50	19.95	36.05	35.13
358	6	8 a.m.		60 19′ 2 17′		0	6 .00	20.01	36.13	35.23
359	6	4 p.m.		61 11′ 2 10′		0	6 .60	19.95	36.05	35.13
360	7	8 a.m.		61 46′ 1 34′		0	7 .20	19.89	35.96	35.04
361	8	8 a.m.		63 6′ 1 0′		0	6 .50	19.85	35.88	34.96
362	8	5 p.m.		63 48′ 0 55′		0	5 .50	19.85	35.88	34.96
363	9	8 a.m.		65 30′ 0 40′		0	5 .00	19.85	35.88	34.96
364	9	12 noon		65 58′ 0 36′		0	5 .00	19.85	35.88	34.96
365	9	5 p.m.		66 32′ 0 30′ E.		0	5 .00	19.89	35.96	35.04
366	10	8 a.m.		68 15′ 0 16′ W.		0	4 .50	20.01	36.13	35.23
367	10	12 noon		68 39′ 0 19′ W.		0	4 .20	19.89	35.96	35.04
368	10	4 p.m.		69 2′ 0 21′ W.		0	4 .50	19.89	35.96	35.04
369	10	9 p.m.		69 26′ 0 26′ W.		0	4 .00	19.89	35.96	35.04
370	11	8 a.m.		70 39′ 0 56′ E.		0	3 .50	19.89	35.96	35.04
371	11	12 noon		70 59′ 1 20′		0	3 .50	19.89	35.96	35.04
372	11	4 p.m.		71 20′ 0 58′		0	3 .50	19.89	35.96	35.04
373	11	8 p.m.		71 39′ 0 54′		0	3 .50	19.85	35.88	34.96
374	12	8 a.m.		72 25′ 0 40′		0	— 1 .20	19.58	35.40	34.51
375	12	12 noon		72 45′ 0 12′ E.		0	—2.00[1]	19 58	35.40	34.51
376	12	6 p.m.		72 55′ 0 15′ W.		0	—2.00[2]	19.69	35.60	34.70
b) Utsire—Arctic Ocean, Capt. O. Simonsen (continued),										
	April					Meter				
377	24	1 p.m.		71° 8′ 1 59′ W.		0	+2°.70	19.81	35.80	34.89
378	27	1 p.m.		70 30′ 1 8′ W.		0	+4 .00	19.81	35.80	34.89
	May									
379	1	1 p.m.		69 54′ 3 45′ W.		0	+3 .00	19.76	35.72	34.81
380	3	12 noon		69 6′ 6 12′ W.		0	+1 .20	19.69	35.60	34.70
381	4	4 p.m.		68 30′ 7 20′ W.		0	— 0 .50	19.50	35.25	34.36
382	6	12 noon		67 42′ 7 57′ W.		0	— 1 .00	19.50	35.25	34.36
383	7	8 p.m.		67 35′ 9 19′ W.		0	— 1 .00	19.42	35.10	34.23
384	15	8 a.m.		67 29′ 10 30′ W.		0	— 1 .00	19.42	35.10	34.23
c) Shields—Stavanger.										
	Febr.					Meter				
385	20	8 p.m.		55°13′ 1 70′ W.		0	5°.40	19.68	35.58	34.68
386	20	10 p.m.		55 29′ 0 41′ W.		0	6 .00	19.79	35.78	34.86
387	20	12 midn.		55 45′ 0 15′ W.		0	6 .00	19.97	36.08	35.16
388	21	2 a.m.		56 1′ 0 11′ E.		0	6 .00	20.01	36.16	35.23
389	21	4 a.m.		56 18′ 0 38′ E.		0	5 .90	20.05	36.23	35.30
390	21	6 a.m.		56 34′ 1 60′		0	5 .70	20.05	36.23	35.30
391	21	8 a.m.		56 48′ 1 29′		0	5 .80	20.05	36.23	35.30
392	21	10 a.m.		57 10′ 1 50′		0	5 .90	20.12	36.36	35.45
393	21	12 noon		57 16′ 2 15′		0	5 .50	20.08	36.28	35.35
394	21	2 p.m.		57 30′ 2 40′		0	4 .80	20.08	36.28	35.35
395	21	4 p.m.		57 45′ 3 7′		0	4 .20	20.01	36.16	35.23
396	21	6 p.m.		57 59′ 3 32′		0	5 .40	20.06	36.25	35.33
397	21	8 p.m.		58 14′ 3 56′		0	5 .70	20.01	36.16	35.23
398	21	10 p.m.		58 28′ 4 22′		0	3 .20	18.61	33.66	32.81
399	21	12 midn.		58 42′ 4 48′		0	3 .20	18.53	33.50	32.69
400	22	2 a.m.		59 0′ 5 17′		0	3 .60	18.83	34.05	33.20
d) Christianssand—Newcastle, S/S „Prospero".										
						Meter				
401	27	4 p.m.		58° 0′ 8 6′ E.		0	3°.80	18.66	33.76	32.93
402	27	6 p.m.		57 52′ 7 44′ E.		0	3 .80	19.20	34.72	33.87
403	27	8 p.m.		57 45′ 7 20′		0	5 .00	19.36	35.00	34.13
404	27	10 p.m.		57 37′ 6 54′		0	5 .00	19.08	34.51	33.65
405	27	12 midn.		57 30′ 6 30′		0	4 .40	18.95	34.27	33.43
406	28	2 a.m.		57 22′ 6 5′		0	5 .00	19.86	35.89	34.97
407	28	4 a.m.		57 14′ 5 40′		0	4 .40	19.82	35.85	34.92
408	28	6 a.m.		57 6′ 5 11′		0	4 .00	19.82	35.85	34.92
409	28	8 a.m.		56 57′ 4 42′		0	4 .00	19.82	35.85	34.92
410	28	10 a.m.		56 49′ 4 14′		0	4 .40	19.82	35.85	34.92
411	28	12 noon		56 40′ 3 46′		0	4 .70	19.82	35.85	34.92
412	28	2 p.m.		56 32′ 3 17′		0	5 .00	19.86	35.89	34.97

[1]) Ice. — [2]) Ice.

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Saline contents Salt per litre	Saline contents Salt per mille
d) Christianssand—Newcastle, S/S „Prospero“ (continued).										
413	Febr. 28	4 p.m.		56°22′ 2 48′		Meter 0	5°.00	19.90	35.98	35.05
414	28	6 p.m.		56 14′ 2 21′		0	5 .60	19.82	35.85	34.92
415	28	8 p.m.		56 5′ 1 55′		0	5 .60	19.82	35.85	34.92
416	28	10 p.m.		55 57′ 1 29′		0	5 .60	19.90	35.98	35.05
417	28	12 midn.		55 49′ 1 2′		0	5 .90	19.82	35.85	34.92
418	March 1	2 a.m.		55 41′ 0 35′		0	5 .60	19.82	35.85	34.92
419	1	4 a.m.		55 32′ 0 7′ E.		0	5 .60	19.77	35.72	34.81
420	1	6 a.m.		55 23′ 0 18′ W.		0	6 .30	19.73	35.66	34.75
421	1	8 a.m.		55 19′ 0 46′ W.		0	5 .90	19.61	35.44	34.54
422	1	10 a.m.		55 5′ 1 15′ W.		0	5 .60	19.16	34.65	33.79
e) Christianssand—Antwerpen, S/S „Odin“.										
423	14	6½ p.m.		Oxö Beacon		Meter 0	2°.00	18.50	33.45	32.65
424	14	8 p.m.		57°50′ 7 55′		0	2 .00	18.70	33.82	33.00
425	14	10 p.m.		57 34′ 7 42′		0	2 .00	19.16	34.65	33.79
426	14	12 midn.		57 16′ 7 28′		0	4 .00	19.73	35.66	34.75
427	15	2 a.m.		57 0′ 7 15′		0	2 .00	19.19	34.69	33.84
428	15	4 a.m.		56 43′ 7 0′		0	2 .00	19.57	35.38	34.50
429	15	6 a.m.		56 26′ 6 45′		0	2 .00	19.65	35.53	34.63
430	15	8 a.m.		56 9′ 6 30′		0	2 .00	19.57	35.38	34.50
431	15	10 a.m.		55 53′ 6 18′		0	2 .00	19.40	35.06	34.20
432	15	12 noon		55 40′ 6 6′		0	3 .00	19.48	35.21	34.33
433	15	4 p.m.		55 15′ 6 0′		0	3 .50	19.47	35.19	34.32
434	15	6 p.m.		54 57′ 5 55′		0	4 .00	19.57	35.38	34.50
435	15	8 p.m.		54 38′ 5 40′		0	3 .50	19.57	35.38	34.50
436	15	10 p.m.		54 23′ 5 32′		0	3 .50	19.57	35.38	34.50
437	15	12 midn.		54 6′ 5 25′		0	4 .00	19.53	35.30	34.40
438	16	2 a.m.		53 53′ 5 5′		0	4 .50	19.44	35.14	34.27
439	16	4 a.m.		53 38′ 4 50′		0	4 .50	19.57	35.38	34.50
e) Christianssand—Antwerpen, S/S „Odin“ (continued).										
440	Febr. 16	6 a.m.		53°22′ 4 35′		Meter 0	5°.00	19.95	36.05	35.13
441	16	8 a.m.		53 7′ 4 25′		0	5 .00	19.67	35.57	34.67
442	16	10 a.m.		Haaks Beacon		0	5 .00	19.87	35.91	35.00
443	16	12 noon		52°45′ 4 8′		0	5 .00	19.84	35.86	34.95
444	16	2 p.m.		52 29′ 3 55′		0	5 .00	19.60	35.42	34.53
445	16	4 p.m.		52 12′ 3 45′		0	5 .00	19.34	34.96	34.10
446	16	6 p.m.		51 57′ 3 35′		0	5 .50	19.10	34.53	33.68
447	16	8 p.m.		Schauwen Beacon		0	6 .00	19.01	34.38	33.54
f) Antwerpen—Christianssand, S/S „Odin“.										
448	20	1 p.m.		Schauwen Beacon		Meter 0	6°.50	19.14	34.60	33.76
449	20	4 p.m.		52°16′ 3 48′		0	5 .50	19.21	34.74	33.88
450	20	6 p.m.		52 35′ 4 3′		0	5 .50	19.57	35.38	34.50
451	20	8 p.m.		Haaks Beacon		0	5 .50	19.83	35.83	34.93
452	20	10 p.m.		53°13′ 4 33′		0	5 .50	19.34	34.96	34.10
453	20	12 midn.		Terschelling Beacon		0	5 .00	19.77	35.72	34.81
454	21	2 a.m.		53°44′ 5 2′		0	5 .00	19.64	35.52	34.62
455	21	4 a.m.		54 0′ 5 15′		0	5 .00	19.57	35.38	34.50
456	21	6 a.m.		54 17′ 5 25′		0	4 .50	19.41	35.08	34.21
457	21	8 a.m.		54 33′ 5 35′		0	4 .50	19.53	35.30	34.40
458	21	10 a.m.		54 50′ 5 45′		0	4 .00	19.61	35.45	34.54
459	21	12 noon		55 6′ 5 56′		0	4 .00	19.57	35.38	34.50
460	21	2 p.m.		55 25′ 6 6′		0	4 .00	19.53	35.30	34.40
461	21	4 p.m.		55 43′ 6 18′		0	3 .50	19.37	35.01	34.14
462	21	8 p.m.		56 18′ 6 42′		0	3 .00	19.21	34.74	33.88
463	21	12 midn.		56 52′ 7 10′		0	3 .00	19.41	35.08	34.21
464	22	4 a.m.		57 26′ 7 35′		0	3 .00	19.51	35.28	34.38
465	22	6 a.m.		57 44′ 7 48′		0	2 .50	18.38	33.23	32.46
466	22	8 a.m.		Oxö		0	2 .00	18.41	33.29	32.51

V. Observations from Lofoten February—April 1897.

(O. Nordgaard).

467	Febr. 5		Höla (Lofoten)	Meter 0	2°.80	19.01	34.40	33.54		
468	5		In the middle of the Östnæsfjord	0	2 .80	18.94	34.27	33.42		
469	5		Sildpoldnæs (Östnæsfjord	0	2 .80	18.40	33.29	32.49		
470	Febr. 6		The harbour of Eidet (Vesteraalen)	Meter 0	2°.20	19.17	34.68	33.82		
471			At Nykerne (Vesteraalen)	0	3 .80	19.17	34.68	33.82		

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	April				Meter	Meter				
472	8			At Frugga 68°50′ N. 14°36′.5 E.	110	0	3°.80	19.23	34.78	33.92
						20	4 .00	19.16	34.66	33.80
						50	4 .00	19.16	34.66	33.80
						100	4 .00	19.16	34.66	33.80
						110	3 .80	19.16	34.66	33.80
473	10			68°51′.25N. 14°31′ E.	170	0	3 .90	19.20	34.74	33 87
						50	4 .20	19.23	34.78	33.92
						100	4 .20	19.23	34.78	33.92
						150	4 .35	19.23	34.78	33.92
						170	4 .35	19.23	34.78	33.92
474	10			Sunderö harbour		0	3 .50	19.23	34.78	33.92
475	12			At Dybingen (Sunderö)		0	3 .40	19.23	34.78	33.92
476	14	4 a.m.		69° 1′.75N. 15°10′. E.		0	3 .20	19.23	34.78	33.92
477	17			Höla (Lofoten)	115	0	2 .40	18.94	34.27	33.42
						30	2 .40	18.94	34.27	33.42
						50	2 .40	18.94	34.27	33.42
						100	2 .70	19.01	34.40	33.54
						115	3 .50	19.16	34.66	33.80
478	19			Höla (Lofoten)	120	0	2 .10	18.91	34.22	33.36
						50	2 .30	18.94	34.27	33.42
						100	4 .20	19.16	34.66	33.80
						120	4 .70	19.23	34.78	33.92
479	19					0	1 .90	18.87	34.15	33.30
						50	2 .20	18.91	34.22	33.36
						100	2 .10	18.91	34.22	33.36
480	19			Themouth off Raftsund	114	0	2 .80	18.83	34.08	33.23
						30	3 .00	19.16	34.66	33.80
						50	3 .50	19.20	34.74	33.87
						100	5 .80	19.56	35.37	34.48
						114	5 .70	19.56	35.37	34.48
481	22			Höla (Lofoten)		0	2 .20	18.91	34.22	33.36
						50	2 .30	18.94	34.27	33.42
						100	4 .70	19.23	34.78	33.92
482	22			At Helle (Östnæsfj.)		0	1 .80	18.83	34.08	33.23
						50	2 .20	18.87	34.15	33.30
						100	2 .60	18.98	34.34	33.49
483	22			At Langstrand (Östnæsfj.)	80	0	1 .20	18.51	33.49	32.68
						50	1 .90	18.87	34.15	33.30
						80	1 .90	18.91	34.22	33.36
484	23			Themouth off Ögsfjord	150	0	1 .40	18.84	34.09	33.25
						10	2 .10	18.98	34.34	33.49
						50	2 .30	18.98	34.34	33.49
						100	2 .60	19.05	34.47	33.61
						145	2 .70	19.05	34.47	33.61
485	23			Between Barö and Lödingen		0	2 .60	19.08	34.57	33.66
						50	2 .70	19.16	34.66	33.80
						100	3 .50	19.23	34.78	33.92
486	24	8 a.m.		Themouth off Tjeldsund		0	2 .60	19.01	34.40	33.54
						20	2 .60	19.01	34.40	33.54
						50	2 .60	19.01	34.40	33.54
						100	3 .30	19.12	34.59	33.73
						150	6 .00	19.66	35.55	34.65
						200	6 .20	19.84	35.87	34.96
487	24			Out off Ramsund (Ofotenfj.)		0	2 .60	18.80	34.01	33.18
488	24			Inside Ramsund (Ofotenfj)		0	2 .00	18.80	34.01	33.18
489	24			At Liland (Ofotenfj.)		0	1 .80	19.01	34.40	33.54
						20	2 .00	19.01	34.40	33.54
						50	2 .00	19.01	34.40	33.54
						80	2 .00	19.05	34.47	33.61
						100	2 .00	19.05	34.47	33.61
						150	6 .00	19.76	35.73	34.82
						300	6 .10	19.87	35.92	35.02

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Salt per litre	Salt per mille
	April				Meter	Meter				
490	25			Out of the Ofoten church		0	2°.00	19.01	34.40	33 54
						30	2 .20	19.01	34.40	33.54
						50	2 .20	19.05	34.47	33.61
						120	2 .80	19.12	34.59	33.73
						150	6 .00	19.66	35.55	34.65
						250	6 .10	19.84	35.87	34.96
491	25	7½ a.m.		Liland harbour (Ofotenfj.)		0	0 .80	18.73	33.88	33.06
492	25	9 a.m.		Out off Liland (Ofotenfj.)		0	1 .60	18.87	34.15	33.30
493	25	12 noon		Out off Ramsund (Ofotenfj.)		0	2 .20	18.80	34.01	33.18
494	25	1 p.m.		Themouth of the (Ofotenfj.)		0	2 .40	18.87	34.15	33.30
495	March 5			St. I Liland (Östnæsfj.)	40	0	1 .30	19.01	34.40	33.54
						30	1 .40	18.98	34.34	33.49
						40	1 .40	18.98	34.34	33.49
496	5			St. II Vestpollen (Östnæsfj.)	23	0	0 .50	18.94	34.27	33.42
						10	0 .50	18.87	34.14	33 30
						23	0 .70	18.91	34.22	33.36
497	5			St. III Langstrand (Östnæsfj.)	50	0	1 .00	18.98	34.34	33.49
						10	1 .20	18.94	34.27	33.42
						50	2 .80	19.09	34.54	33.68
498	5			St. IV Stordalen (Östnæsfj.)	65	0	1 .00	18.94	34.27	33.42
						50	2 .50	19.05	34.47	33 61
						65	3 .20	19.12	34.59	33.73
499	5			St. V Vaterfjord (Östnæsfj.)	140	0	1 .20	18.94	34.27	33.42
						10	1 .30	18.91	34.22	33.36
						50	3 .00	19.09	34.54	33.68
						140	3 .60	19.16	34.66	33.80
500	5			St. VI Helle (Östnæsfj.)	120	0	1 .50	18.98	34.34	33.49
						10	1 .50	19.01	34.40	33.54
						50	1 .60			
						100	3 .70	19.19	34.72	33.86
						120	4 .10	19.23	34.79	33.92
501	5			R. I At Slotholm (Öhellesund)	110	0	1 .90	18.98	34.34	33.49
						50	3 .10	19.09	34.54	33.68
						100	3 .50	19.16	34.66	33 80
						110	3 .60			
502	5			R. II Raftsund	90	0	2 .20	18.98	34.34	33.49
						50	3 .30	19.09	34.54	33.68
						90	3 .50	19.12	34.59	33.73
503	5			R. III Themouth of the Grundfj.	50	0	2 .20	19.05	34 54	33.61
						50	3 .10	19.12	34.59	33.73
504	5			M. R. Out of the Raftsund and East of Lille Molla		0	3 .00	19.12	34.59	33.73
						30	3 .20	19.12	34.59	33.73
						50	3 .20	19.12	34 59	33.73
						100	3 .20	19.12	34.59	33.73
						110	3 .50	19.19	34.72	33.86
						150	6 .50	19.80	35.80	34.89
505	5			Höla (Lofoten)	130	0	2 .40			
						50	2 .50	19.05	34.47	33.61
						100	2 .70	19.09	34.54	33.68
						130	4 .70	19.34	34.99	34.11
506	7			St. I The inner end of the Troldfjord The fjord was frozen from the mouth to the inner end	65	0	0 .10	0.40	0.75	0.73
						2	3 .10			
						5	3 .10			
						10	3 .10			
						50	3 .10	19.01	34.40	33.54
						65	5 .30	19.34	34.99	34.11

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
					Meter	Meter				
507	7			St. II	55	0	2°.20	18.80	34.01	33.18
				The mouth		10	2 .70			
				of the		50	3 .20	19.12	34.59	33.73
				Troldfjord		55	3 .20			
				At the edge of the ice						
508	10			St. I	50	0	— 0 .30	18.80	34.01	33 18
				Liland		10	0 .30	18.91	34.22	33 36
				(Östnæsfj.)		30	1 .50			
						50	2 .10	19.05	34.47	33.61
509	10			St. II	55	0	0 .20	18.91	34.22	33.36
				Smaaskjær		50	3 .20	19.09	34.54	33.68
				(Östnæsfj.)						
510	10			St. III		0	1 .40	18.87	34.14	33.30
				Vaterfjord		50	2 .50	19.01	34.40	33.54
				(Östnæsfj.)		100	3 .50	19.12	34.59	33.73
511	10			Höla	137	0	2 .30	19.09	34.54	33.68
				(Lofoten)		10	2 .30	19.05	34.47	33.61
						30	2 .30			
						50	2 .40	19.09	34.54	33.68
						100	2 .50	19.09	34.54	33.68
						137	4 .60	19.34	34.99	34.11
512	10			M.	170	0	3 .10	19.12	34.59	33.73
				6½ miles		50	3 .10	19.12	34.59	33.73
				S off		100	3 .20	19.19	34.72	33.86
				Örsvaag		125	5 .40	19.48	35.23	34.35
						150	6 .50	19.80	35.80	34.89
						170	6 .50			
513	10			L. i.	270	270	6 .40	19.84	35.87	34.96
				8¼ miles						
				S off						
				Örsvaag						
514	10			H.		0	3 .10	19.12	34.59	33.73
				4 miles		10	3 .10			
				SSO off		50	3 .10	19.12	34.59	33.73
				Hennings-vær		100	3 .10	19.12	34.59	33.73
515	11			S.	50	0	1 .80	19.05	34.47	33.61
				3¾ miles		50	2 .80	19.09	34.54	33.68
				WtN off						
				Hennings-vær						
516	11			X.	110	0	2 .20	19.01	34.40	33.54
				7 miles		10	2 .50			
				SO off		50	2 .60	19.01	34.40	33.54
				Stamsund		100	3 .10	19.01	34.40	33.54
						110	3 .10			
517	11			V.	70	0	2 .60	19.12	34.59	33.73
				8 miles		50	2 .70	19.12	34.59	33.73
				SSO off		70	3 .30	19.12	34.59	33.73
				Stamsund						
518	11			U.	80	0	3 .10	19.12	34.59	33.73
				5½ miles		50	3 .10	19.12	34.59	33.73
				SSO off		80	3 .10	19.12	34.59	33.73
				Ure						
519	11			B.	65	0	1 .80	19.09	34.54	33.68
				4 miles		50	3 .10	19.12	34.59	33.73
				SSW off		65	3 .20			
				Balstad						
520	17			Lerfjord	25	0	3 .50	18.72	33.87	33.04
				(Helge-land)		10	3 .80	19.12	34.59	33.73
						25	3 .80	19.12	34.59	33.73
521	18			At Stöt		0	2 .70	19.12	34.59	33.73
				(Kunna)						
522	18			The mouth of the Saltenfjord		0	2 .70	19.22	34.77	33.91

No.	1897 Date	1897 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
					Meter	Meter				
523	18			At Grötö		0	1°.20	19.12	34.59	33.73
524	19			6 miles		0	2 .70	19.22	34.77	33.91
				N off						
				Grötö						
525	19			In the		0	2 .80	19.25	34.82	33.96
				middle of						
				the						
				Vestfjord						
				between						
				Grötö and						
				Skraaven						
526	19			Höla		0	2 .20	19.18	34.70	33.84
527	20			Balstad		0	0 .80	18.85	34.11	33.26
				harbour						
528	30			St. 1	115	0	2 .80	19.27	34.86	33.99
				5 miles		10	2 .80	19.24	34.80	33.94
				SO off		50	2 .80	19.24	34.80	33.94
				Reine		100	3 .50	19.42	35.12	34.24
						115	3 .70			
					April					
529	1			St. I	100	0	2 .80	19.24	34.80	33.94
				5 miles		10	2 .80	19.24	34.80	33.94
				StO off		50	2 .80	19.24	34.80	33.94
				Reine		80	2 .80	19.24	34.80	33.94
						100	3 .20	19.42	35.12	34.24
530	1			St. II	60	0	2 .60	19.24	34.80	33.94
				2 miles		10	2 .60	19.24	34.80	33.94
				StW off		50	2 .60	19.24	34.80	33.94
				Reine		60	2 .80	19.27	34.86	33.99
531	6			St. 1	150	0	2 .70	19.20	34.73	33.87
				9 miles		10	2 .80	19.20	34.73	33.87
				SOtO off		50	3 .20	19.31	34.93	34.06
				Reine		100	5 .40	19.64	35.52	34.62
						150	5 .70	19.67	35.57	34.67
532	6			St. II		0	3 .10	19.24	34.80	33.94
				5 miles		50	3 .30	19.34	34.99	34.11
				SSO off		100	4 .30	19.45	35.18	34.30
				Reine						
533	9			St. I	90	0	2 .50	19.16	34.66	33.18
				3½ miles		10	2 .50	19.16	34.66	33.18
				SO½O off		50	2 .60	19.16	34.66	33.18
				Balstad		90	4 .30	19.38	35.05	34.18
534	9			St. II	115	0	2 .80	19.24	34.80	33.94
				8½ miles		30	2 .80			
				SOtS off		50	2 .80	19.24	34.80	33.94
				Balstad		80	3 .40	19.31	34.93	34.06
						100	5 .60	19.60	35.45	34.55
						115	5 .90	19.67	35.57	34.67
535	10			St. I	200	0	3 .00	19.24	34.80	33.94
				12 miles		20	2 .90	19.20	34.73	33.87
				SSO off		50	3 .30	19.27	34.86	33.99
				Balstad		80	3 .50	19.31	34.93	34.06
						100	5 .40	19.56	35.37	34.48
						150	6 .60	19.82	35.83	34.92
						200	6 .60	19.82	35.83	34.92
536	20					0	1 .70	19.23	34.80	33.92
537	20					0	1 .70	19.26	34.84	33.97
538	28			St. I	140	0	4 .60	19.34	34.99	34.11
				4½ miles		10	4 .60	19.38	35.05	34.18
				NW off		50	4 .60	19.45	35.18	34.30
				Röst (the		100	4 .60	19.53	35.32	34.43
				church)		140	5 .00	19.67	35.57	34.67
					Mai					
539	1			St. I		0	4 .50	19.38	35.05	34.18
				4 miles		50	4 .50	19.38	35.05	34.18
				E off		100	4 .50	19.38	35.05	34.18
				Skomvær		150	4 .70	19.45	35.18	34.30

VI. Surface observations in the North Sea 1896,

made by Capt. Thovsen, S/S „Mercur".

Bergen—Newcastle.

No.	1896 Date	Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents: Cl. per litre	Salt per litre	Salt per mille
1	Jan. 29	6 p.m.		60° 0′ N. 1 47′ E.	Meter 0	7°.60	18.90	34.20	33.35
2	29	8 p.m.		59 44′ N. 4 2′.6 E.	0	7 .00	18.97	34.33	33.47
3	29	10 p.m.		59 27′ N. 4 3′ E.	0	7 .20	18.85	34.11	33.27
4	29	12 midn.		59 13′ N. 3 15′ E	0	6 .90	19.64	35.52	34.62
5	30	2 a.m.		58 55′.7 N. 3 23′ E.	0	7 .40	19.68	35.59	34.69
6	30	4 a.m.		58 37′.5 N. 3 0′ E.	0	6 .80	19.81	35.81	34.90
7	30	6 a.m.		58 20′ N. 2 39′ E.	0	6 .90	19.88	35.95	35.03
8	30	8 a.m.		58 1′.5 N. 2 15′ E.	0	7 .00	19.88	35.95	35.03
9	30	10 a.m.		57 43′ N. 1 52′ E.	0	6 .80	19.88	35.95	35.03
10	30	12 noon		57 25′ N. 1 30′ E.	0	7 .10	19.88	35.95	35.03
11	30	2 p.m.		57 9′ N. 1 10′	0	7 .10	19.88	35.95	35.03
12	30	4 p.m.		56 49′.5 N. 0 47′ E.	0	7 .60	19.88	35.95	35.03
13	30	6 p.m.		56 30′ N. 0 23′ E.	0	7 .20	19.88	35.95	35.03
14	30	8 p.m.		56 12′ N 0 2′ E.	0	7 .00	19.88	35.95	35.03
15	30	10 p.m.		55 53′ N. 0 25′ W.	0	7 .00	19.88	35.95	35.03
16	30	12 midn.		55 41′ N. 0 55′ W.	0	6 .90	19.81	35.81	34.91
17	31	2 a.m.		55 20′ N. 1 0′.5W.	0	6 .80	19.74	35.70	34.79
18	31	4 a.m.		55 4′ N. 1 21′ W.	0	6 .70	19.66	35.55	34.65
1	Febr. 26	6 p.m.		60 5′ N. 4 58′ E.	0	5 .30	18.87	34.15	33.31
2	26	8 p.m.		59 48′ N. 4 34′ E.	0	5 .40	19.01	34.40	33.54
3	26	10 p.m.		59 29′ N. 4 8′ E.	0	6 .00	19.66	35.55	34.65
4	26	12 midn.		59 15′ N. 3 48′ E.	0	6 .40	19.89	35.96	35.01
5	27	2 a.m.		58 57′.5 N. 3 25′ E	0	6 .50	19.93	36.04	35.11
6	27	4 a.m.		58 39′.5 N. 3 0′ E.	0	6 .20	19.85	35.90	34.97
7	27	6 a.m.		58 22′ N. 2 37′.5 E.	0	6 .20	19.89	35.96	35.01
8	27	8 a.m.		58 4′ N. 2 13′ E.	0	6 .00	19.89	35.96	35.04
9	27	10 a.m.		57 49′ N. 1 53′.5 E.	0	6 .40	19.83	35.85	34.94
10	27	12 noon		57 39′.5 N. 1 40′ E.	0	6 .60	19.83	35.85	34.94
11	27	2 p.m.		57 31′ N. 1 30′ E.	0	6 .60	19.83	35.85	34.94
12	27	4 p.m.		57 21′ N. 1 15′ E.	0	6 .70	19.77	35.75	34.84
13	27	6 p.m.		57 10′.5 N. 0 58′.5 E.	0	6 .50	19.83	35.85	34.94
14	27	8 p.m.		56 57′ N. 0 37′ E.	0	6 .30	19.81	35.81	34.91
15	27	10 p.m.		56 42′ N. 0 12′.5 E.	0	6 .20	19.58	35.41	34.52
16	27	12 midn.		56 25′ N. 0 13′ W.	0	6 .20	19.68	35.59	34.69
17	28	2 a.m.		56 9′ N. 0 39′ W.	0	6 .20	19.70	35.62	34.72
18	28	4 a.m.		55 52′ N. 1 7′ W.	0	6 .20	19.71	35.64	34.71
19	28	6 a.m.		55°32′.5 N. 1 17′ W	Meter 0	6°.20	19.83	35.85	34.91
20	28	8 a.m.		55 10′ N. 1 18′ W.	0	5 .90	19.58	35.41	34.52
1	March 25	6 p.m.		60 2′ N. 4 48′ E.	0	4 .60	18.81	34.03	33.20
2	25	8 p.m.		59 44′ N. 4 26′ E.	0	5 .20	19.04	34.45	33.59
3	25	10 p.m.		59 25′.5 N. 4 1′ E.	0	5 .80	19.58	35.41	34.52
4	25	12 midn.		59 7′ N. 3 38′.5 E.	0	6 .20	19.65	35.54	34.61
5	26	2 a.m.		58 49′ N. 3 14′ E.	0	6 .20	19.96	36.09	35.17
6	26	4 a.m.		58 35′ N. 2 56′ E.	0	6 .80	19.96	36.09	35.17
7	26	6 a.m.		58 16′.5 N. 2 31′ E.	0	6 .80	19.88	35.95	35.03
8	26	8 a.m.		57 57′.5 N. 2 10′ E.	0	6 .40	19.86	35 91	34.99
9	26	10 a.m.		57 39′ N. 1 47′ E.	0	6 .20	19.82	35.83	34.92
10	26	12 noon		57 20′ N. 1 24′.5 E.	0	6 .00	19.80	35.80	34.89
11	26	2 p.m.		57 1′.5 N. 1 0′.5 E.	0	6 .20	19.82	35.83	34.92
12	26	4 p.m.		56 44′ N. 0 40′ E.	0	6 .50	19.82	35.83	34.92
13	26	6 p.m.		56 27′ N. 0 19′.5 E.	0	6 .40	19.82	35.83	34.92
14	26	8 p.m.		56 9′ N. 0 1′ W.	0	6 .20	19.82	35.83	34.92
15	26	10 p.m.		55 50′.5 N. 0 25′ W.	0	7 .00	19.82	35.83	34.92
16	26	12 midn.		55 31′.5 N. 0 15′ W.	0	7 .00	19.75	35.71	34.80
17	27	2 a.m.		55 14′ N. 1 7′ W.	0	6 .80	19.53	35.32	34.43
18	27	4 a.m.		55 3′.5 N. 1 18′ W.	0	6 .60	19.57	35.39	34.50
1	April 22	12 midn.		59 59′ N. 4 44′ E.	0	5 .40	18.37	33.23	32.44
2	23	2 a.m.		59 41′.5 N. 4 20′ E.	0	5 .20	18.37	33.23	32.44
3	23	4 a.m.		59 21′.5 N. 3 52′ E.	0	6 .00	18.73	33.89	33.06
4	23	6 a.m.		59 3′ N. 3 25′ E.	0	6 .50	19.19	34.71	33.86
5	23	8 a.m.		58 44, N. 3 0′ E.	0	7 .40	20.00	36.15	35.22
6	23	10 a.m.		58 24′ N. 2 32′ E.	0	7 .00	19.82	35.83	34.92
7	23	12 noon		58 6′ N. 2 7′ E.	0	6 .80	19.88	35.95	35.03
8	23	2 p.m.		57 48′ N. 1 43′ E.	0	7 .20	19.80	35 80	34.89
9	23	4 p.m.		57 29′.5 N. 1 18′ E.	0	7 .20	19.88	35.95	35.03
10	23	6 p.m.		57 9′ N. 0 52′ E.	0	7 .20	19.80	35.80	34.89
11	23	8 p.m.		56 51′ N. 0 29′ E.	0	7 .20	19.80	35.80	34.89
12	23	10 p.m.		56 32′ N. 0 5′ E.	0	6 .80	19.80	35.80	34.89
13	23	12 midn.		56 14′ N. 0 20′ W.	0	6 .90	19.69	35.60	34.70
14	24	2 a.m.		55 58′ N. 0 40′ W.	0	7 .10	19.69	35.60	34.70
15	24	4 a.m.		55 39′ N. 1 7′ W.	0	7 .20	19.69	35.60	34.70
16	24	6 a.m.		55 18′ N. 1 20′ W.	0	7 .80	19.55	35.35	34.47

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Saline contents Salt per litre	Saline contents Salt per mille
	June					Meter				
1	2	10 a.m.		58°44′ N. 4 53′ E.		0	10°.00	19.27	34.86	33.99
2	2	12 noon		58 29′ N. 4 20′ E.		0	10 .60	19.38	35.06	34.18
3	2	2 p.m.		58 12′ N. 4 2′ E.		0	10 .60	19.11	34.57	33.71
4	2	4 p.m.		57 55′ N. 3 30′ E.		0	10 .50	19.50	35.26	34.38
5	2	6 p.m.		57 38′ N. 3 1′ E.		0	11 .20	19.73	35.68	34.77
6	2	8 p.m.		57 22′ N. 2 35′ E.		0	11 .20	19.73	35.68	34.77
7	2	10 p.m.		57 12′ N. 2 12′ E.		0	10 .50	19.88	35.95	35.03
8	2	12 midn.		56 50′ N. 1 38′ E.		0	10 .70	19.96	36.09	35.16
9	3	2 a.m.		56 33′ N. 1 10′ E.		0	10 .40	19.88	35.95	35.03
10	3	4 a.m.		56 18′ N. 0 44′ E.		0	10 .50	19.88	35.95	35.03
11	3	6 a.m.		56 1′ N. 0 15′ E.		0	10 .40	19.80	35.80	34.89
12	3	8 a.m.		55 44′ N. 0 12′ W.		0	10 .70	19.80	35.80	34.89
13	3	10 a.m.		55 22′ N. 0 40′ W.		0	10 .90	19.77	35.75	34.84
1	30	9 a.m.		58 52′ N. 5 14′ E.		0	10 .00	18.92	34.23	33.39
2	30	11 a.m.		58 36′ N. 4 46′ E.		0	11 .20	18.38	33.25	32.46
3	30	1 p.m.		58 21′ N. 4 17′ E.		0	13 .60	17.88	32.34	31.60
4	30	3 p.m.		58 4′ N. 3 47′ E.		0	13 .30	18.38	33.25	32.46
5	30	5 p.m.		57 48′ N. 3 17′ E.		0	12 .40	19.77	35.75	34.84
6	30	7 p.m.		57 34′ N. 2 55′ E.		0	12 .80	19.77	35.75	34.84
7	30	9 p.m.		57 17′ N. 2 25′ E.		0	12 .80	19.80	35.80	34.89
8	30	11 p.m.		57 0′ N. 1 56′ E.		0	12 .70	19.88	35.95	35.03
	July									
9	1	1 a.m.		56 44′ N. 1 29′ E.		0	12 .60	19.96	36.09	35.16
10	1	3 a.m.		56 27′ N. 0 59′ E.		0	13 .40	19.88	35.95	35.03
11	1	5 a.m.		56 10′ N. 0 31′ E.		0	12 .60	19.84	35.87	34.95
12	1	7 a.m.		55 52′ N. 0 1′ E.		0	13 .10	19.80	35.80	34.89
13	1	9 a.m.		55 35′ N. 0 27′ W.		0	13 .20	19.77	35.75	34.84
14	1	11 a.m.		55 18′ N. 0 56′ W.		0	12 .60	19.57	35.39	34.50
1	28	9 a.m.		58 54′ N. 5 19′ E.		0	15 .60	17.60	31.83	31.11
2	28	11 a.m.		58 40′ N. 4 52′ E.		0	14 .60	18.11	32.76	32.00
3	28	1 p.m.		58 26′ N. 4 26′ E.		0	14 .90	17.81	32.22	31.48
4	28	3 p.m.		58 9′ N. 3 56′ E.		0	15 .20	18.96	34.31	33.45
5	28	5 p.m.		57 52′ N. 3 26′ E.		0	15 .40	18.75	33.92	33.10
6	28	7 p.m.		57 35′ N. 2 56′ E.		0	15 .20	19.34	34.98	34.11
7	28	9 p.m.		57 19′ N. 2 29′ E.		0	14 .60	19.65	35.52	34.64
8	28	11 p.m.		57 2′ N. 2 0′ E.		0	14 .20	19.79	35.78	34.88
9	29	1 a.m.		56 45′ N. 1 32′ E.		0	13 .30	19.79	35.78	34.88
10	29	3 a.m.		56 28′ N. 1 3′ E.		0	13 .60	19.73	35.68	34.77
11	29	5 a.m.		56 12′ N. 0 34′ E.		0	14 .00	19.73	35.68	34.77
12	29	7 a.m.		55 56′ N. 0 7′ E.		0	14 .20	19.73	35.68	34.77

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Saline contents Salt per litre	Saline contents Salt per mille
						Meter				
13	29	9 a.m.		55°39′ N. 0 20′ W.		0	14°.60	19.69	35.60	34.70
14	29	11 a.m.		55 22′ N. 0 47′ W.		0	14 .40	19.57	35.39	34.50
15	29	1 p.m.		55 5′ N. 1 15′ W.		0	13 .80	19.50	35.26	34.38
	Sept.									
1	5	7 p.m.		55 4′ N. 1 16′ W.		0	13 .80	19.40	35.08	34.21
2	5	9 p.m.		55 18′ N. 0 55′ W.		0	14 .10	19.60	35.44	34.55
3	5	11 p.m.		55 33′ N. 0 32′ W.		0	14 .40	19.70	35.62	34.72
4	6	1 a.m.		55 49′ N. 0 6′ W.		0	14 .10	19.77	35.75	34.84
5	6	3 a.m.		56 4′ N. 0 21′ E.		0	14 .20	19.81	35.82	34.91
6	6	5 a.m.		56 18′ N. 0 45′ E.		0	14 .00	19.77	35.75	34.84
7	6	7 a.m.		56 33′ N. 1 10′ E.		0	13 .80	19.84	35.87	34.96
8	6	9 a.m.		56 48′ N. 1 36′ E.		0	14 .20	19.70	35.62	34.72
9	6	11 a.m.		57 4′ N. 2 0′ E.		0	14 .40	19.67	35.57	34.67
10	6	1 p.m.		57 20′ N. 2 25′ E.		0	14 .40	19.40	35.08	34.21
11	6	3 p.m.		57 36′ N. 2 51′ E.		0	14 .70	18.82	34.05	33.21
12	6	5 p.m.		57 51′ N. 3 17′ E.		0	14 .60	18.62	33.69	32.87
13	6	7 p.m.		58 7′ N. 3 43′ E.		0	14 .20	18.89	34.18	33.34
14	6	9 p.m.		58 23′ N. 4 10′ E.		0	14 .30	18.17	32.87	32.10
15	6	11 p.m.		58 38′ N. 4 36′ E.		0	15 .20	17.66	31.94	31.21
16	7	1 a.m.		58 55′ N. 5 4′ E.		0	16 .00	17.60	31.83	31.11
1	26	8 p.m.		55 10′ N. 1 8′ W.		0	11 .80	19.43	35.14	34.26
2	26	10 p.m.		55 27′ N. 0 41′ W.		0	12 .00	19.64	35.52	34.62
3	26	12 midn.		55 43′ N. 0 16′ W.		0	11 .60	19.67	35.57	34.67
4	27	2 a.m.		56 0′ N. 0 10′ E.		0	11 .80	19.70	35.62	34.72
5	27	4 a.m.		56 16′ N. 0 37′ E.		0	12 .00	19.74	35.70	34.79
6	27	6 a.m.		56 33′ N. 1 3′ E.		0	12 .00	19.77	35.75	34.84
7	27	8 a.m.		56 49′ N. 1 29′ E.		0	12 .10	19.77	35.75	34.84
8	27	10 a.m.		57 5′ N. 1 56′ E.		0	12 .00	19.70	35.62	34.72
9	27	12 noon		57 23′ N. 2 24′ E.		0	12 .00	19.60	35.44	34.55
10	27	2 p.m.		57 40′ N. 2 52′ E.		0	11 .80	19.36	35.02	34.14
11	27	4 p.m.		57 55′ N. 3 18′ E.		0	13 .30	18.96	34.31	33.46
12	27	6 p.m.		58 12′ N. 3 42′ E.		0	12 .70	18.89	34.18	33.34
13	27	8 p.m.		58 28′ N. 4 14′ E.		0	12 .90	18.14	32.81	32.04
14	27	10 p.m.		58 44′ N. 4 41′ E.		0	13 .60	17.22	31.15	30.45
15	27	12 midn.		58 59′ N. 5 7′ E.		0	13 .20	17.05	30.77	30.09
	Nov.									
1	7	7 p.m.		55 3′ N. 1 18′ W.		0	9 .40	19.35	35.00	34.13
2	7	8 p.m.		55 9′ N. 1 9′ W.		0	9 .60	19.42	35.13	34.25
3	7	10 p.m.		55 26′ N. 0 42′ W.		0	9 ·50	19.56	35.37	34.49
4	7	12 midn.		55 40′ N. 0 20′ W.		0	9 .40	19.63	35.50	34.60

No.	1896 Date	1896 Hour	Weather	Locality	Soundings	Depth from which sample obtained	Temperature of the water at that depth	Saline contents Cl. per litre	Saline contents Salt per litre	Saline contents Salt per mille
						Meter				
5	8	2 a.m.		55°54′ N. 0 2′ E.		0	9°.40	19.63	35.50	34.60
6	8	4 a.m.		56 8′ N. 0 19′ E.		0	9 .60	19.70	35.63	34.72
7	8	6 a.m.		56 21′ N. 0 45′ E.		0	9 .40	19.70	35.63	34.72
8	8	8 a.m.		56 34′ N. 1 7′ E.		0	9 .70	19.77	35.75	34.84
9	8	10 a.m.		56 48′ N. 1 28′ E.		0	9 .10	19.77	35.75	34.84
10	8	12 noon		57 2′ N. 1 49′ E.		0	9 .10	19.77	35.75	34.84
11	8	2 p.m.		57 15′ N. 2 12′ E.		0	8 .80	19.77	35.75	34.84
12	8	4 p.m.		57 29′ N. 2 35′ E.		0	8 .20	19.77	35.75	34.84
13	8	6 p.m.		57 43′ N. 2 59′ E.		0	8 .10	19.46	35.20	34.32
14	8	8 p.m.		57 58′ N. 3 23′ E.		0	8 .40	19.42	35.13	34.25
15	8	10 p.m.		58 13′ N. 3 50′ E.		0	8 .40	18.79	34.00	33.16
16	8	12 midn.		58 28′ N. 4 14′ E.		0	9 .00	18.79	34.00	33.16
17	9	2 a.m.		58 42′ N. 4 41′ E.		0	9 .20	17.79	32.18	31.44
18	9	4 a.m.		58 57′ N. 5 7′ E.		0	9 .60	17.92	32.41	31.66
1	28	8 p.m.		55 10′ N. 1 7′ W.		0	9 .80	19.72	35.66	34.75
2	28	10 p.m.		55 25′ N. 0 43′ W.		0	9 .20	19.65	35.54	34.64
3	28	12 midn.		55 39, N. 0 20′ W.		0	8 .90	19.76	35.73	34.82
4	29	2 a.m.		55 54′ N. 0 3′ W.		0	9 .00	19.86	35.91	34.99
5	29	4 a.m.		56 8′ N. 0 28′ E.		0	9 .20	20.00	36.15	35.23
6	29	6 a.m.		56 23′ N. 0 53′ E.		0	9 .00	20.00	36.15	35.23
7	29	8 a.m.		56 37′ N. 1 17′ E.		0	9 .10	20.04	36.23	35.30
8	29	10 a.m.		56 52′ N. 1 43′ E.		0	9 .20	20.04	36.23	35.30
9	29	12 noon		57 8′ N. 2 9′ E.		0	8 .60	19.93	36.04	35.10
10	29	2 p.m.		57 23, N. 2 36′ E.		0	7 .80	19.97	36.11	35.18
11	29	4 p.m.		57 39′ N. 3 3′ E.		0	7 .70	19.72	35.66	34.75
12	29	6 p.m.		57 56′ N. 3 31′ E.		0	8 .20	19.97	36.11	35.18
13	29	8 p.m.		58 10′ N. 3 57′ E.		0	8 .20	19.54	35.34	34.45
14	29	10 p.m.		58 25′ N. 4 25′ E.		0	8 .00	19.16	34.66	33.80
15	29	12 midn.		58 40′ N. 4 51′ E.		0	8 .20	18.38	33.25	32.45
16	30	2 a.m.		58 55′ N. 5 19′ E.		0	7 .60	17.85	32.29	31.54
	Decbr.									
1	16	8 p.m.		59 47′ N. 4 32′ E.		0	7 .00	18.84	34.09	33.25
2	16	10 p.m.		59 28′ N. 4 8′ E.		0	6 .40	19.12	34.59	33.73
3	16	12 midn.		59 11′ N. 3 41′ E.		0	6 .40	19.08	34.54	33.68
4	17	2 a.m.		58°52′ N. 3 20′ E.		0	7°.20	19.72	35.66	34.75
5	17	4 a.m.		58 31′ N. 2 57′ E.		0	7 .50	19.83	35.86	34.94
6	17	6 a.m.		58 16′ N. 2 33′ E.		0	6 .90	19.86	35.91	34.99
7	17	8 a.m.		57 58′ N. 2 12′ E.		0	6 .80	19.86	35.91	34.99
8	17	10 a.m.		57 40′ N. 1 49′ E.		0	6 .80	20.00	36.15	35.23
9	17	12 noon		57 22′ N. 1 25′ E.		0	7 .40	20.07	36.28	35.34
10	17	2 p.m.		57 2′ N. 1 1′ E.		0	8 .10	20.07	36.28	35.34
11	17	4 p.m.		56 43′ N. 0 38′ E.		0	8 .20	20.07	36.28	35.34
12	17	6 p.m.		56 25′ N. 0 15′ E.		0	8 .60	20.00	36.15	35.23
13	17	8 p.m.		56 6′ N. 0 8′ W.		0	8 .60	19.93	36.04	35.12
14	17	10 p.m.		55 47′ N. 0 30′ W.		0	8 .20	19.90	35.99	35.06
15	17	12 midn.		55 28′ N. 0 52′ W.		0	7 .70	19.72	35.66	34.75
16	18	2 a.m.		55 9′ N. 1 15′ W.		0	7 .80	19.61	35.46	34.57
1	30	8 p.m.		59 47′ N. 4 32′ E.		0	7 .50	19.40	35.09	34.21
2	30	10 p.m.		59 28′ N. 4 7′ E.		0	7 .20	19.15	34.65	33.78
3	30	12 midn.		59 12′ N. 3 45′ E.		0	7 .80	19.47	35.22	34.34
4	31	2 a.m.		58 56′ N. 3 25′ E.		0	7 .80	19.64	35.51	34.62
5	31	4 a.m.		58 44′ N. 3 10′ E.		0	7 .40	19.99	36.14	35.21
6	31	6 a.m.		58 32′ N. 2 54′ E.		0	7 .30	19.96	36.09	35.16
7	31	8 a.m.		58 18′ N. 2 36′ E.		0	7 .10	19.89	35.96	35.04
8	31	10 a.m.		58 3′ N. 2 17′ E.		0	7 .10	19.78	35.78	34.85
9	31	12 noon		57 47′ N. 1 56′ E.		0	8 .00	20.10	36.33	35.39
10	31	2 p.m.		57 30′ N. 1 36′ E.		0	7 .60	20.03	36.20	35.28
11	31	4 p.m.		57 15′ N. 1 17′ E.		0	7 .30	19.96	36.09	35.16
12	31	6 p.m.		56 59′ N. 0 57′ E.		0	7 .80	19.99	36.14	35.21
13	31	8 p.m.		56 44′ N. 0 39′ E.		0	7 .50	20.07	36.28	35.34
14	31	10 p.m.		56 29′ N. 0 20′ E.		0	8 .00	19.99	36.14	35.21
15	31	12 midn.		56 15′ N. 0 4′ E.		0	8 .20	19.99	36.14	35.21
	Jan.									
16	1	2 a.m.		56 5′ N. 0 8′ W.		0	8 .00	19.96	36.09	35.16
17	1	4 a.m.		55 53′ N. 0 23′ W.		0	8 .00	19.92	36.01	35.09
18	1	6 a.m.		55 36′ N. 0 42′ W.		0	7 .80	19.75	35.70	34.80
19	1	8 a.m.		55 20′ N. 1 3′ W.		0	7 .40	19.68	35.59	34.69
20	1	10 a.m.		55 3′ N. 1 21′ W.		0	6 .80	19.32	34.95	34.07

PLANKTON TABLES

NOTES.

The samples were gathered by means of small bags of fine canvas (No. 16 or 18). These were either towed along near the surface of the water. or sunk to a certain depth, for instance 50 metres, and hauled straight up. The given temperature and salinity, in the latter instance refers to that at the greatest depth reached by the bag. The occurrence of the various Plankton Organisms is represented by the following symbols.

c c = very common.

c = common.

\+ = not rare.

r = rare.

2. Samples from the cruise Sognefjord—Iceland, May 1896,

with H. M. S. "Heimdal".

See the hydrografic tables A. III.

Month	May																							
Date	12		13								14						15				16		18	
Station	42		43		44		46		50		54		58		62		66		70		71		72	
Depth in meter	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100
Temperature in degrees of Celsius	7.0	7.45	8.4	7.6	8.4	8.0	9.6	8.8	8.4	7.0	6.4	4.7	5.2	3.6	5.0	3.1	3.2	1.8	2.8	2.0	2.1	0.6	0.9	— 0.1
Saline contents in $^0/_{00}$	32.8	35.8	32.7	35.2	33.7	35.1	35.4	35.4	35.3	35.3	35.1	35.1	34.4	35.0	34.9	35.0	34.9	34.9	34.8	34.9	34.4	34.9	34.4	34.8
Diatoms.																								
a) Oceanic forms.																								
Coscinodiscus oculus iridis Ehb....							+	+			c	c	c	cc	r	+	r	r	r					
— radiatus									r		r													
Rhizosolenia alata Brightw.							r	r	+	+														
— styliformis Brightw.....												r	r	+		+								
— semispina Hensen.....							r	r	+	r			r	r										
Chaetoceros atlanticum Cl.				r			r	+		r	+	+	+	c	r	+					r		r	
— boreale Bail.....				r			r	r																
— criophilum Castr.....							+	+	r	r	+	+	r	+	r	+								
— decipiens Cl.		r					c	cc	c	c	c	c	+	c	r	+	r							
Thalassiothrix longissima Cl.							+	r			c	c	c	c	+	c	r	r	r	r		r	r	r
b) Neritic summer forms.																								
Coscinodiscus excentricus Ehb.....								r		r														
Chaetoceros cinctum Gran.							+	+	c	c	+	+												
Nitzschia fraudulenta Cl.									r	r														
— delicatissima Cl.									c	c														
c) Neritic winter forms.																								
Thalassiosira Nordenskiöldii Cl. ...							r																	
— gravida Cl.....									r	r	r	r												
Chaetoceros teres Cl.							+	r			r													
— constrictum Gran.									+	+	r													
— diadema (Ehb.) Gran.							r	r	+	+														
– debile Cl.							+	+	r		+	+												
– scolopendra Cl.							+	+	r		+	+												
Dinoflagellata.																								
Ceratium tripos.....	c	+	cc	c	c	c	r	r	r	r	+	+												
— — v. arctica											+	+	+	r	r	+	r	r	r	r	r	r	r	r
— fusus	+	r	+	+	+	+					r		r							r				
— furca	+	r	+	+	+	+	r																	
Peridinium divergens.....	+	c	+	c	+	c		r	r		+	+												
Dinophysis ocuta	+	r			r	r																		
Diplopsalis leuticula.....	r	r			r	+						r												
Silicoflagellata.																								
Distephanus speculum							+	r		r														

3. Samples taken June 1896

onboard of H. M. S. "Hansten":
See the hydrographic tables A. IV.

Month	June														
Date	11	12			13			14	17				19		
Station	73	74	75	76	77	78	79	80	81	82	83		84		85
Depth in meter	0—60	0—60	0—60	0—60	0—60	0—60	0—60	0—60	0—60	0—60	0	0—60	0	0—60	0
Temperature in degrees of Celsius	7.8	8.4	9.0	9.4	8.7	8.0	7.2	7.2	7.1	7.0	14.3	6.9	12.0.	7.3	10.8
Saline contents in $^0/_{00}$	35.2	35.2	35.2	35.2	35.1	35.1	35.1	35.0	34.6	34.4		34.6	33.5	34.8	
Diatoms.															
a) Oceanic forms.															
Coscinodiscus concinnus W. Sm....				r								r			
Rhizosolenia alata Brightw.....	+	c		r										r	
— semispina Hensen.....														r	
— Shrubsolii Cl.		r												r	
Chaetoceros atlanticum Cl.....			r	r											
— boreale Bail.	+	+	+	r		r	r		r			r		r	
— danicum Cl.....									r						
— decipiens Cl.	+	+	r	r					+	+	+	c	r	+	
Thalassiothrix Frauenfeldii Grun...									+	+	+	+			
b) Neritic summer forms.															
Skeletonema costatum Grev.	+					+	c	r					r	r	
Cerataulina Bergonii Perag.....									r	+		+			
Eucampia Zoodiacus Ehb.	r	r													
Chaetoceros contortum Schütt.....	+	r	r												
— didymum Ehb.	+	+										r			
— laciniosum Schütt.....												r			
— coronatum Gran.	r														
— Willei Gran.	+	r													
— curvisetum Cl.....	+	r	r						+	r					
Nitzschia fraudulenta Cl.	+	c	r	r											
— delicatissima Cl.						+	+								
c) Neritic winter forms.															
Coscinodiscus polychordus Gran. ..		r													
Thalassiosira Nordenskiöldii Cl. ...	c	+		r											
— gravida Cl.....	r	+	r											r	
Leptocylindrus danicus Cl.....	r	+	r											r	
Chaetoceros diadema (Ehb.) Gran..	+					r			r			r			
— debile Cl.	c	+	r	r											
Dinoflagellata.															
Ceratium tripos.....	r	r	+	c	c	c	c	+	c	c	c	c	c	cc	c
— fusus.....		r	r	+	+	+	+	r	+	+	+	+	c	c	c
— furca.....			r	+	+	+	r	r	r	r	+	+	c	c	c
Peridinium divergens.....	r	+	r	+	+	+	+	+	c	c	+	c	c	c	c
Dinophysis rotundata.....	r														

4. Samples from the cruise, May 1897,

with H. M. S. "Heimdal".
See the hydrographic tables A. V.

Month	May																									
Date	11		12						13						14						15		18		21	
Station	88		89		90		91		93		95		97		99		101		103		105		109		112	
Depth in meter	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100	0	0—100
Temperature in degrees of Celsius	5.5	5.3	5.2	6.3	5.4	5.9	6.4	7.7	6.5	6.5	5.0	5.2	4.0	3.3	3.4	3.0	2.2	1.7	1.5	1.1	0.2	0.1	— 0.3	— 0.7	0.8	— 0.1
Saline contents in $^0/_{00}$	32.1	34.3	32.5	35.0	33.9	34.6	34.4	35.1	35.0	35.0	34.8	35.0	34.7	34.7	34.7	34.8	34.7	34.7	34.6	34.6	34.4	34.6	34.4	34.3	34.7	34.5
Diatoms.																										
a) Oceanic forms.																										
Coscinodiscus oculus iridis Ehb.	r	+	+	+	+	c	+	+	r	+	r	r		r								r				
Rhizosolenia semispina Hensen.														r								r				
Chaetoceros atlanticum Cl.				r					r	r												r		r	r	
— boreale Bail				r																						
— criophilum Castr.											r	r														
— decipiens Cl.																										
Thalassiothrix longissima Cl.		r		r					r	r	r	r	r	r		r					r	r	+	r	r	r
b) Neritic arctic forms.																										
Thalassiosira hyalina (Grun.) Gran																								r		
Dinoflagellata.																										
Ceratium tripos	r	+	r	+	r	+	r	+		+										r						
— — v. longipes Bail.	r	c	+	c	+	c	r	c		c		r		r		r				r				r		
— — v. arctica Ehb.									r			r	r	r		r				r						
— — v. macroceros Ehb.			r	r	r																					
— — v. Bucephalos Cl.		r								r																
— fusus		r	r	+	r	+	r	+		r		r														
— furca		r		+	r	r		r																		
Peridinium divergens	r	r		+		r		+		r																
Chlorophyceæ.																										
Halosphæra viridis Schmitz.		r	r		r	r																				

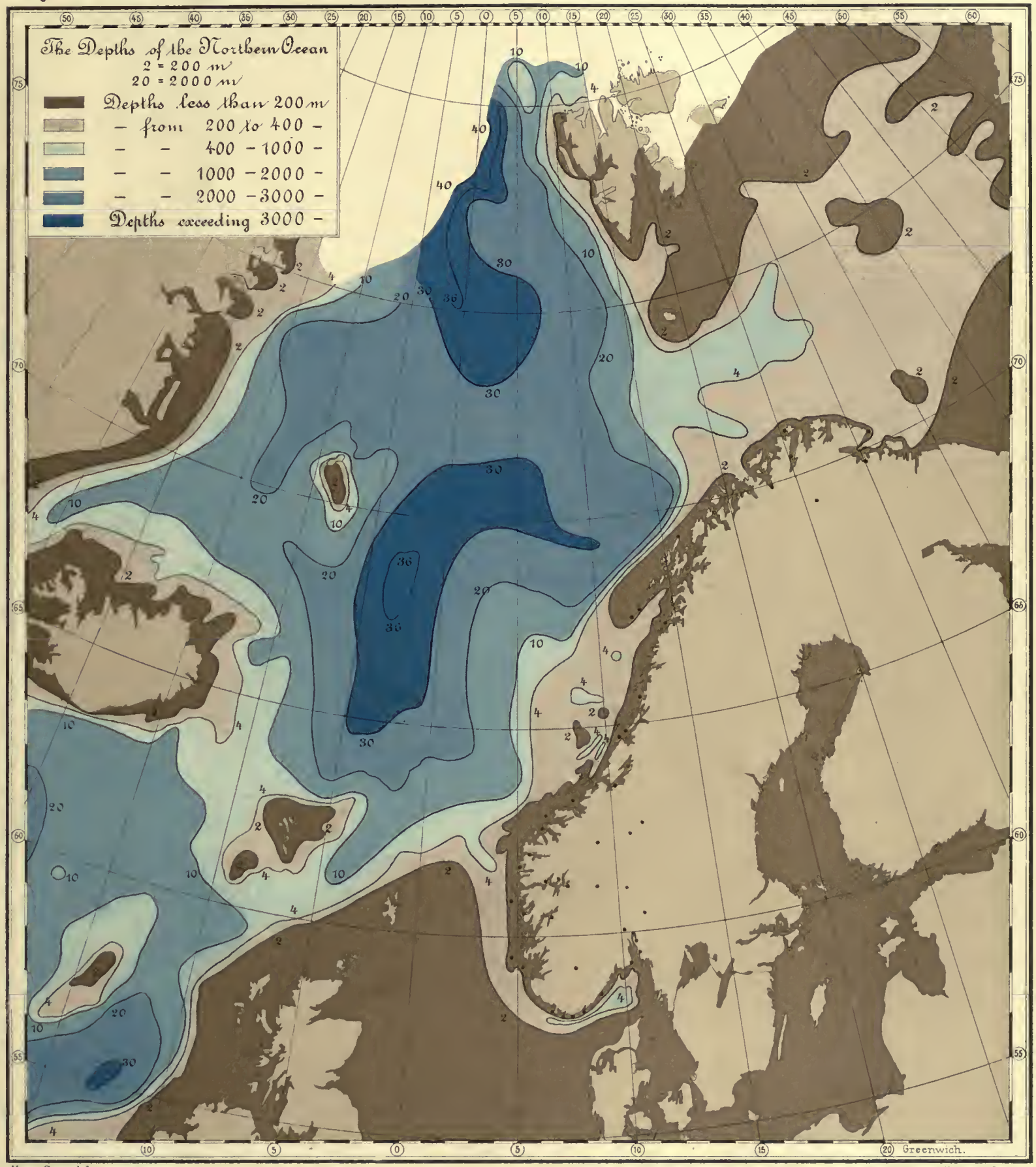
6. Samples from Lofoten, March—April 1896.

See the hydrographic tables B. II.

Month	March												April							
Date	17		23						26				9		13		15			
Station	212		215		216		217		218		219	220	221	222	223	224	225		226	
Depth in meter	0	0—100	0—50	0—100	0	0—100	0	0—100	0	0—100	0—130	0—100	0	0	0	0—50	0	0—50	0	0—30
Temperature in degrees of Celsius	2.5	3.3	3.7	4.8	3.2	4.0	2.8	5.8	2.5	3.9			2.2	1.8	2.8	3.5	3.1	3.6	3.3	3.3
Saline contents in ‰	33.1	33.3	33.6	34.0	33.5	33.7	33.2	34.1	32.8				32.9	32.2	33.1	33.4	33.3	33.5	33.4	33.4
Diatoms.																				
a) Oceanic forms.																				
Coscinodiscus oculus iridis Ehb.	r	r	r			r	r			r	r		+	r		r				r
— concinnus W. Sm.			r				r						+	+				r		
— radiatus Ehb.		r																		
Chaetoceros boreale Bail.		r	r										r		r	r		r	r	
— criophilum Castr.			r									r		r		r	r			r
— decipiens Cl.		+	r	r	r	r	r		+	+	r	r	c	+	c	+	+	+	r	+
Thalassiothrix Frauenfeldii Grun.			r							r	r		r	r		r	r			
b) Neritic summer forms.																				
Skeletonema costatum Grev.	r	r	r			r			+	+	+	r								r
Chaetoceros contortum Schütt.										r	r		r			r	r	r	r	
c) Neritic winter forms.																				
Thalassiosira Nordenskiöldii Cl.			r			r	r		+	+	+	+	+	+	r	+	r	r		
— gravida Cl.					r	r			r	+	r							r	r	
Biddulphia aurita (Lyngb.)			r	r	r		r		r		r	+	r	r			r			r
Chaetoceros teres Cl.														r		r				
— diadema (Ehb.) Gran.											r		r	+	r	r			r	
— debile Cl.				r												r			r	
— sociale Lauder			r						r		+		+	+	r	+			r	r
Nitzschia seriata Cl.											r									
— Closterium W. Sm.										r			r			r	r			
d) Neritic arctic forms.																				
Thalassiosira hyalina (Grun.) Gran.											r	r		r				r		
Chaetoceros furcellatum Bail.			r							r	+	r	+	+	r	r	r	+	+	r
Fragilaria oceanica Cl.			+	+		r	r	r	+	+	+	+	+	+		+		r		r
Dinoflagellata.																				
Ceratium tripos	+	c	r	+	+	+	r	r	r	r	r	r	r	r		r	r	r	r	r
— fusus	+	+	r	r	r	r	r		r	r	r	r					r			r
— furca		+	r	r																
Peridinium divergens	+	+	r	+		r			r	r		r				r	r	r	r	r
Dinophysis acuta		r																		
Flagellata.																				
Phaeocystis Poucheti (Har.) Lagerh.			+	r		r	r		r	+	+	r	+	c	c	c	c	c	c	+
Silicoflagellata.																				
Distephanus speculum (Ehb.)			r															r		
Chlorophyceæ.																				
Halosphaera viridis Schmitz.	+	+	+	+	+	r	r	r	r	r	r	r		r	r					

PLATE 1.

Chart of the Depths of the Northern Ocean. (Mohn: The northern Ocean, Its Depths, Temperature and Circulation, Pl. II).


The Depths of the Northern Ocean
2 = 200 m
20 = 2000 m
Depths less than 200 m
– from 200 to 400 –
– – 400 – 1000 –
– – 1000 – 2000 –
– – 2000 – 3000 –
Depths exceeding 3000 –
Greenwich.

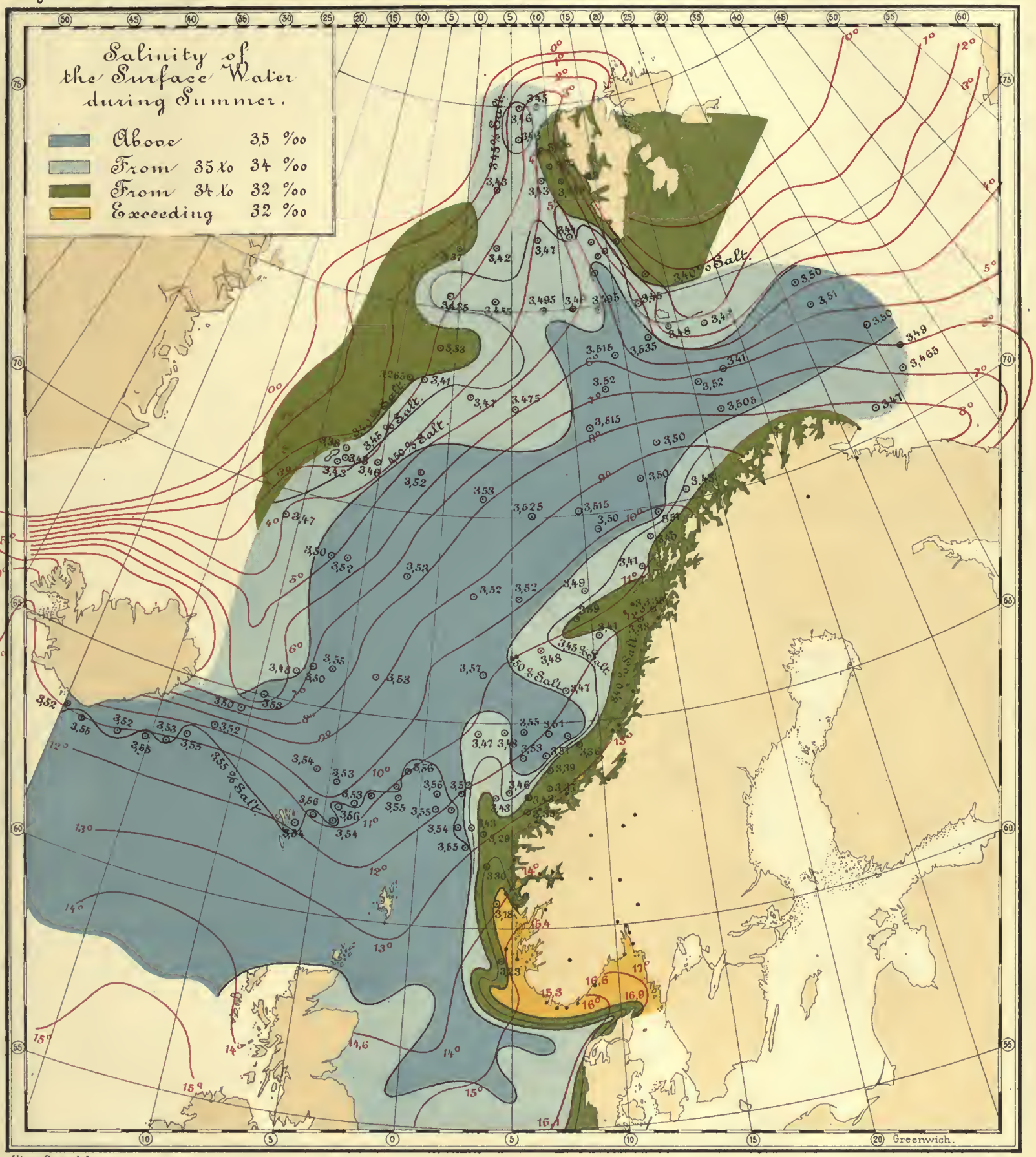
Hjort-Gran del.

Lith. Anst. Julius Klinkhardt, Leipzig

PLATE 2.

Chart of the Northern Ocean, shewing the Salinity and Temperature on the surface during the Summers 1876—78, compiled from Tornöes and Mohn's charts in the Report of the Norwegian Northern Ocean Expedition, supplemented by the results derived from the Drache Expedition.

The Isotherms are printed in red.



Hjort-Gran del.

Lith. Anst. Julius Klinkhardt, Leipzig.

PLATE 3.

Chart of the Northern Ocean, shewing the temperature and salinity on the surface during March and April 1897.

The Isotherms are printed in red.

The black lines indicate the routes on which observations were made. The Surface Observations are denoted by cross lines, the Deep Sea Sounding Stations are indicated by small circles.

See also the Hydrographical Tables B, III—IV, pp. 11—15.

Salinity of the Surface Water March-April 1897.

Above 35 ‰
From 35 ‰ to 34 ‰
From 34 ‰ to 32 ‰

Greenwich.

Hjort-Gran del.

Lith. Anst. Julius Klinkhardt, Leipzig.

PLATE 4.

Fig. 1. Section Sogne Fjord (61° 9′ 5″ N. Lat., 3° 50′ 5″ E. Long.) — Iceland (66° 32′ N. Lat., 7° 15′ W. Long.), May 1896. The Salinity of the various layers is given in the same colours as on Pls. 1—2.

The Isotherms and Temperature are printed in red lines and figures. The coloured double columns under individual Stations represent the occurence of Plankton Organisms. The individual Species are printed to the left of the horizontal lines; the Oceanic Species being denoted by Blue colouring, the Neritic by Red (Southern or Summer Forms); Brown representing the Northern or Winter Forms, and Green the Arctic Forms.

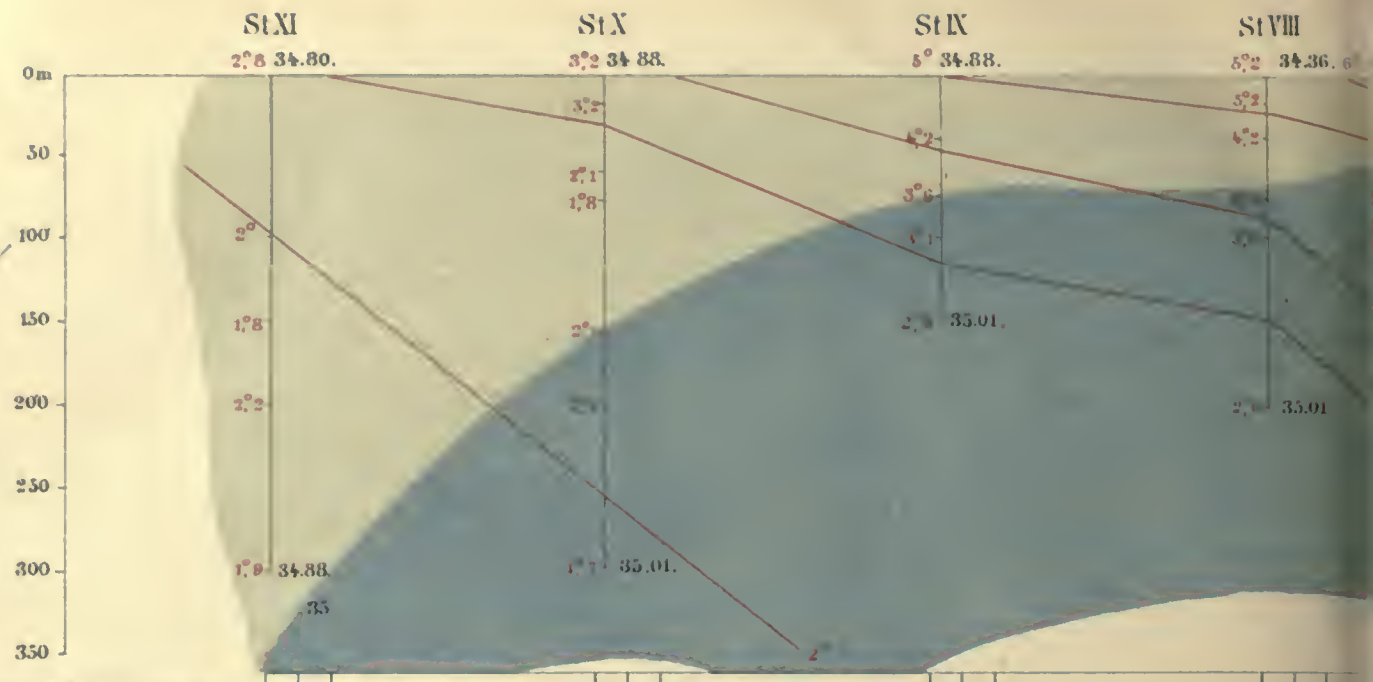
The comparative frequency is given in various tones of colouring, the light tints indicating that the species occurs in few numbers, the darker denoting a plentiful appearance.

See Hydrographical Table A, III, and Plankton Table 2.

Fig. 2. This represents the same Section in May 1897. Hydrographical Table A, V., Plankton Table 4.

Arctic Ocean.

12 - 15 May 1896.

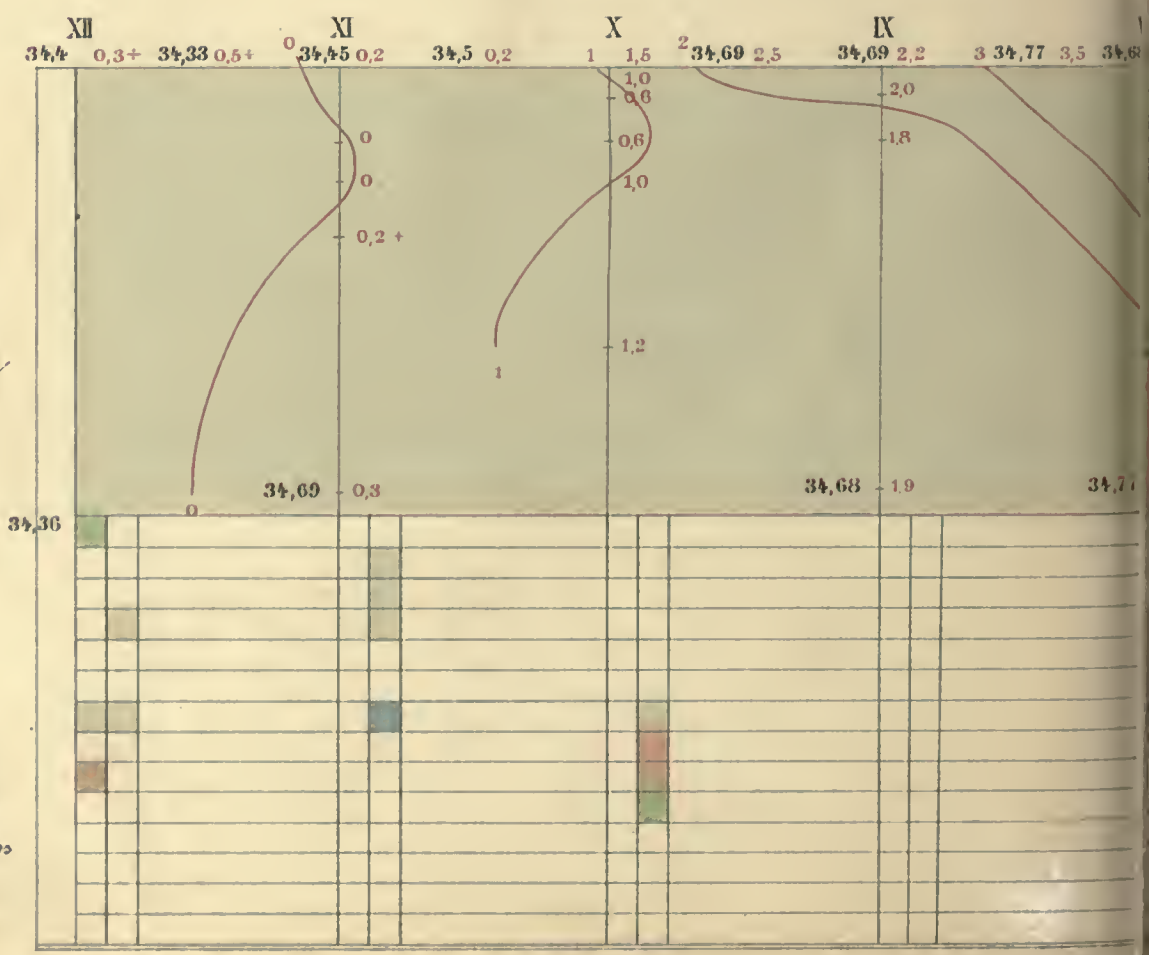


Thalassicolla Nordenskiöldii
— gravida
Coscindiscus excentricus
— oculus iridis
— radiatus
Rhizosolenia obtusa
— semispina
— styliformis
Chaetoceros atlanticum
— criophilum
— decipiens
— constrictum
— diadema
— scolopendra
— debile
— cinctum
Nitzschia delicatissima
Thalassiothrix longissima
Ceratium tripos
— — var. arctica
— fusus
— furca
Peridinium divergens
Dinophysis acuta

Arctic Ocean.

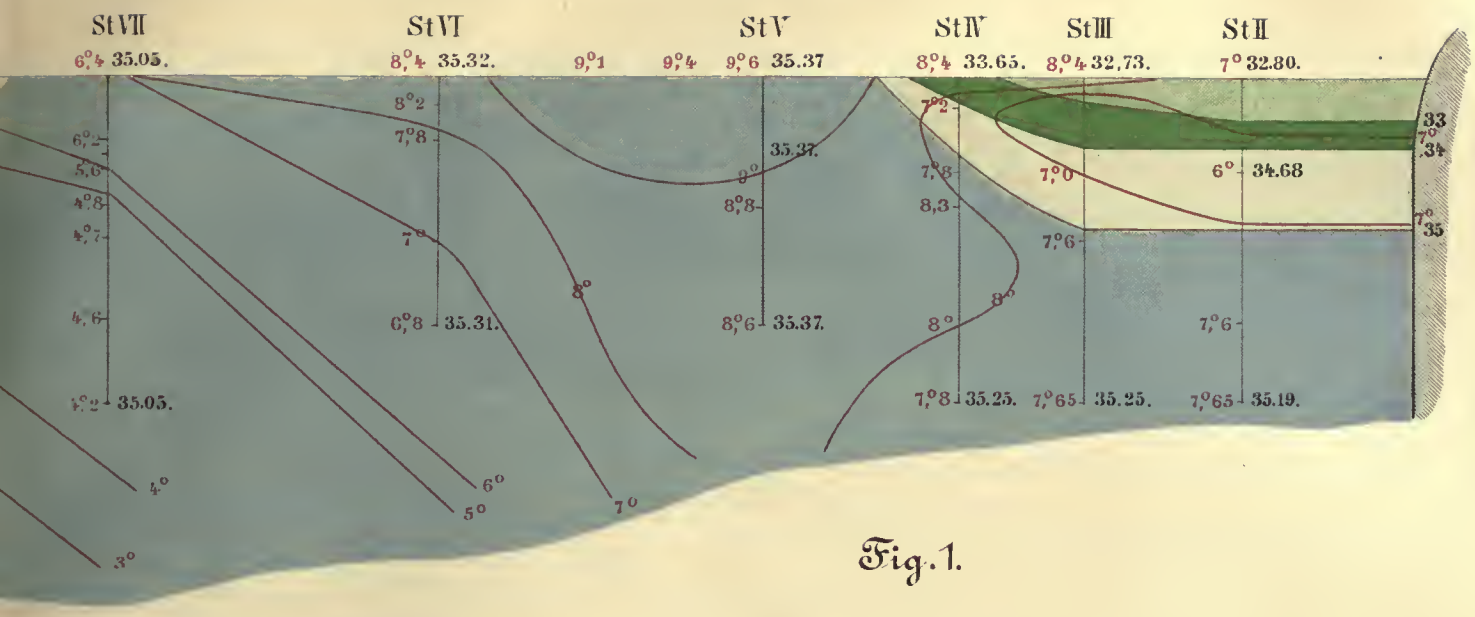
Fig. 2.

11 - 18 May 1897.



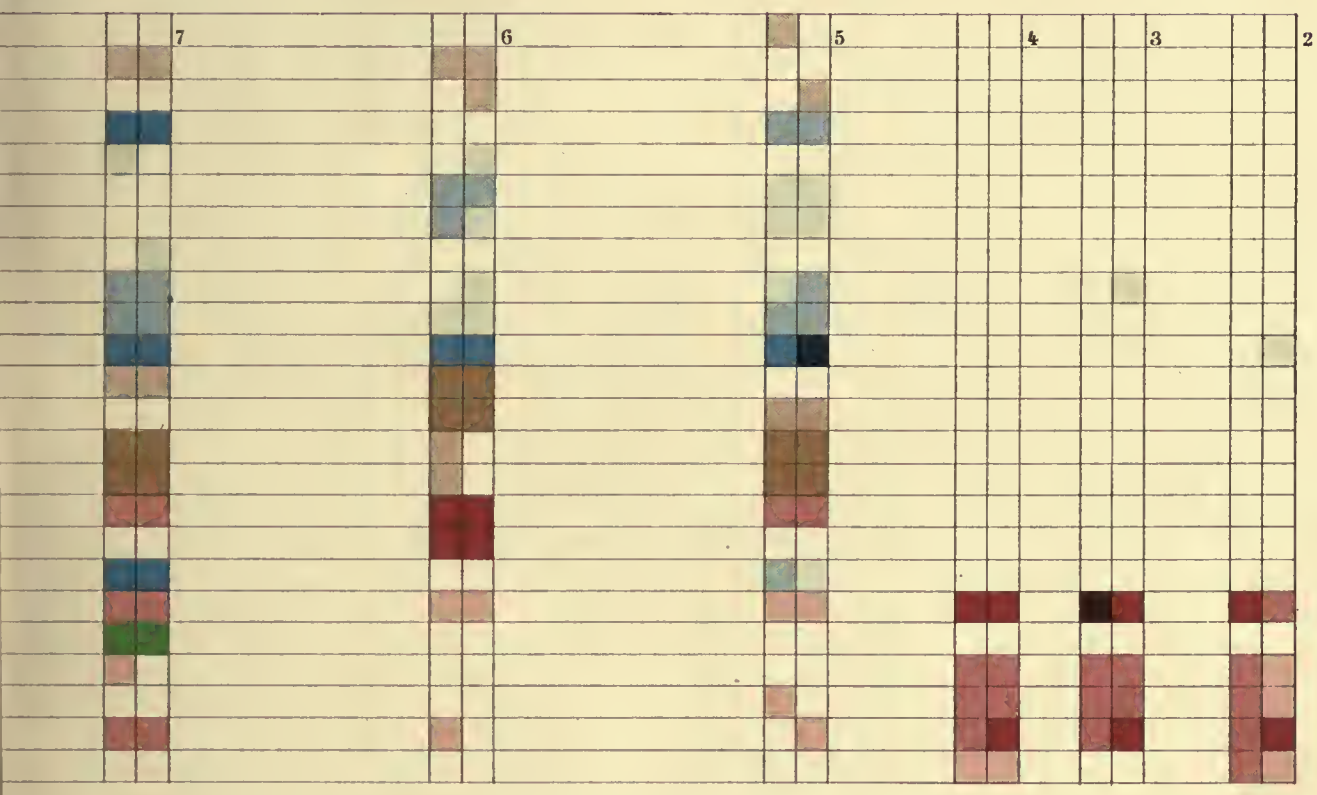
Thalassiosira hyalina
Coscinodiscus oculus iridis
Rhizosolenia semispina
Chaetoceros atlanticum
— criophilum
— decipiens
Thalassiothrix longissima
Ceratium tripos
— — var. longipes
— — var. arctica
— — var. macroceros
— fusus
— furca
Peridinium divergens

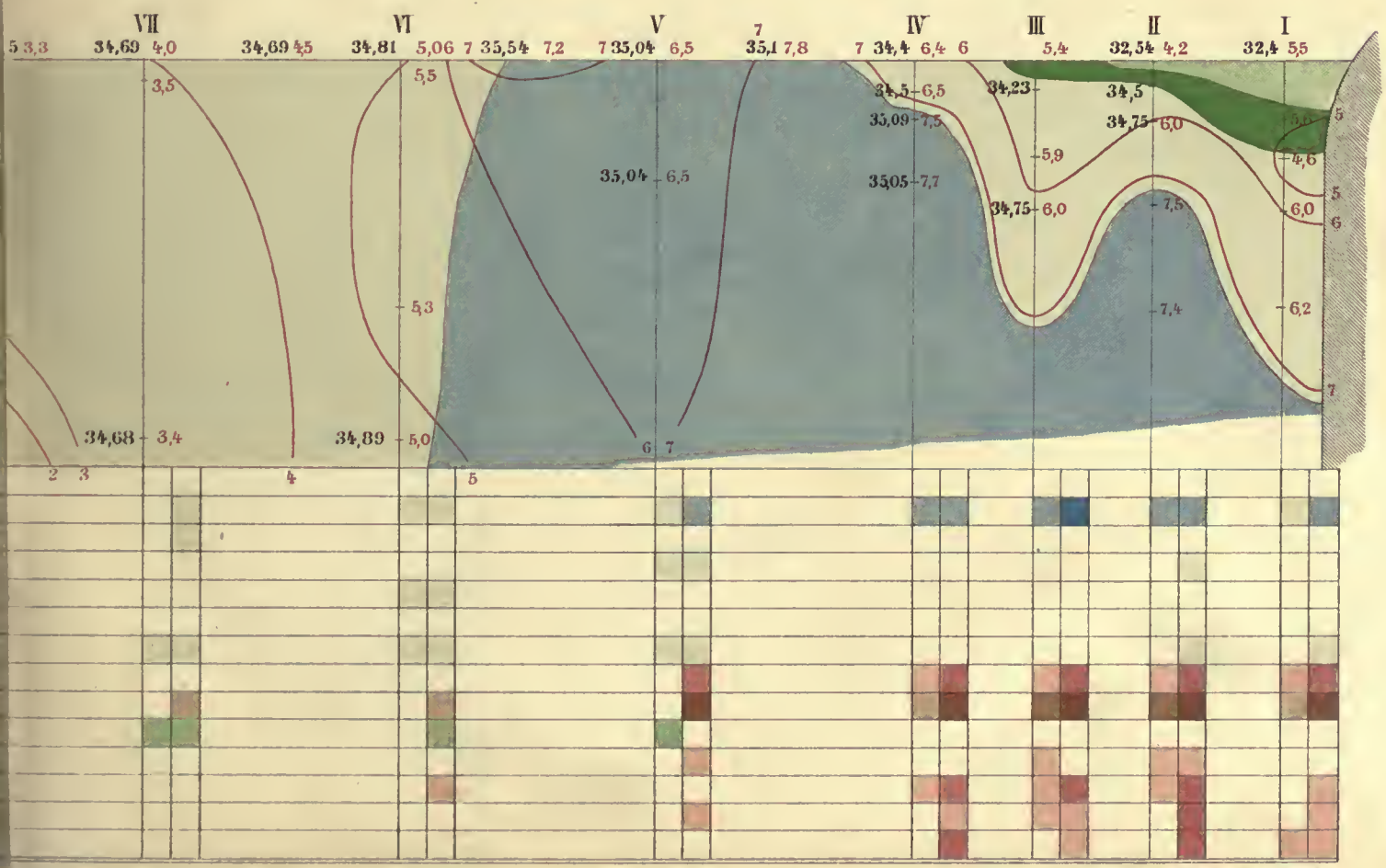
Hjort-Gran del



Sogne Fjord.

Fig. 1.





Sogne Fjord.

Lith. Anst. Julius Klinkhardt Leipzig

PLATE 5.

Fig. 1. Section, Utsire—Iceland, March 1897. This Section is delineated on the Surface Chart, Pl. 3.
See Hydrog. Tab. B. III.

— *2.* Section off Hustadviken near Christianssund. The Isotherms are printed in black.
See Hydrog. Tab. A. IV, Sts. 77—80.

— *3.* Graphic representation of the variations of Temperature at various depths during each month of the year off the West Coast of Norway.

— *4.* Similar representation of the different degrees of Salinity down in the deep throughout the same period at the same place. The colours have the same signification as those on Pls. 2—4.

Iceland.

4th - 10th 9

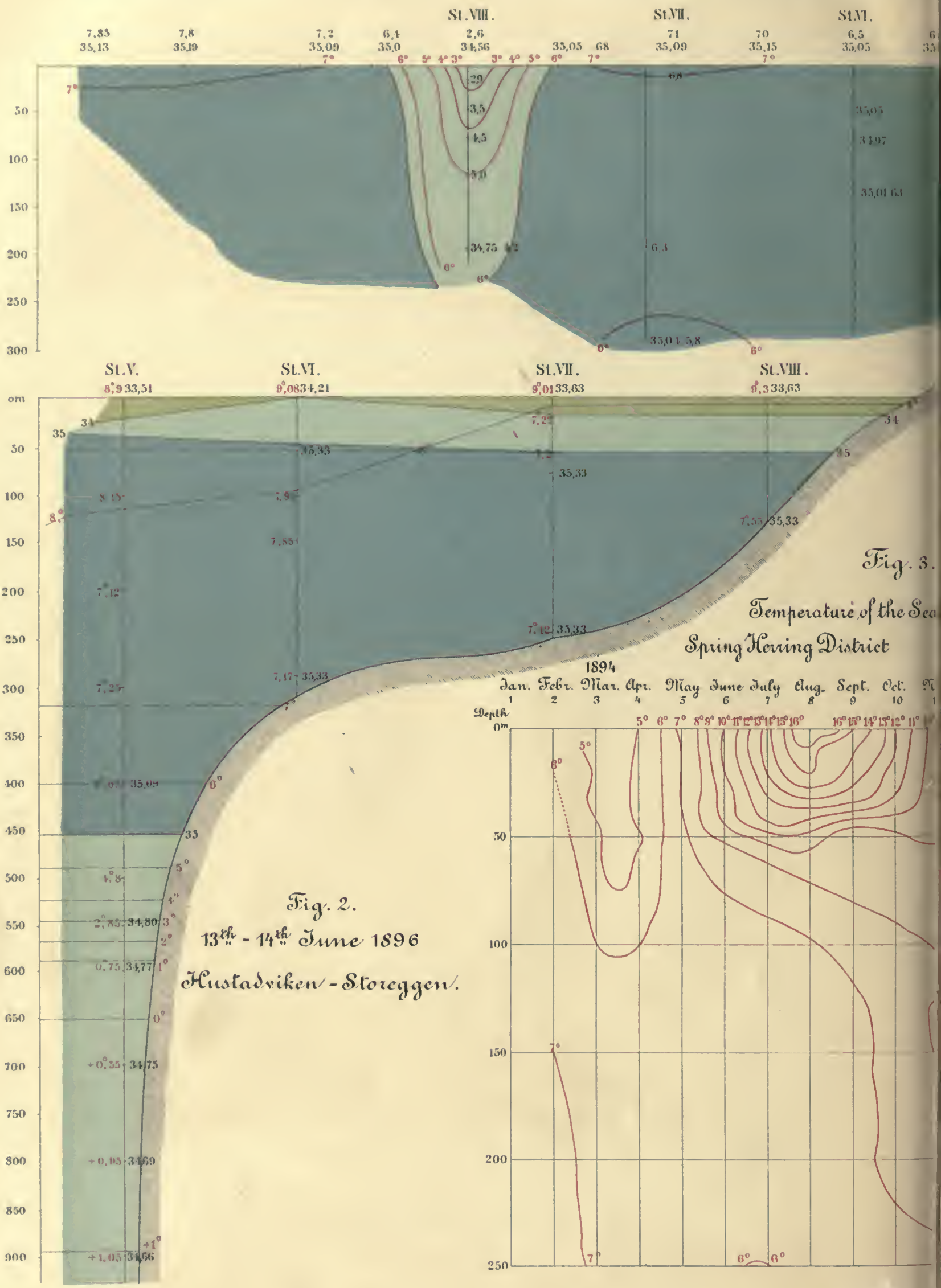


Fig. 3.

Temperature of the Sea
Spring Herring District

Fig. 2.

13th - 14th June 1896

Hustadviken - Storeggen.

Hjort-Grandal

rch 1897.

Ayrshire.

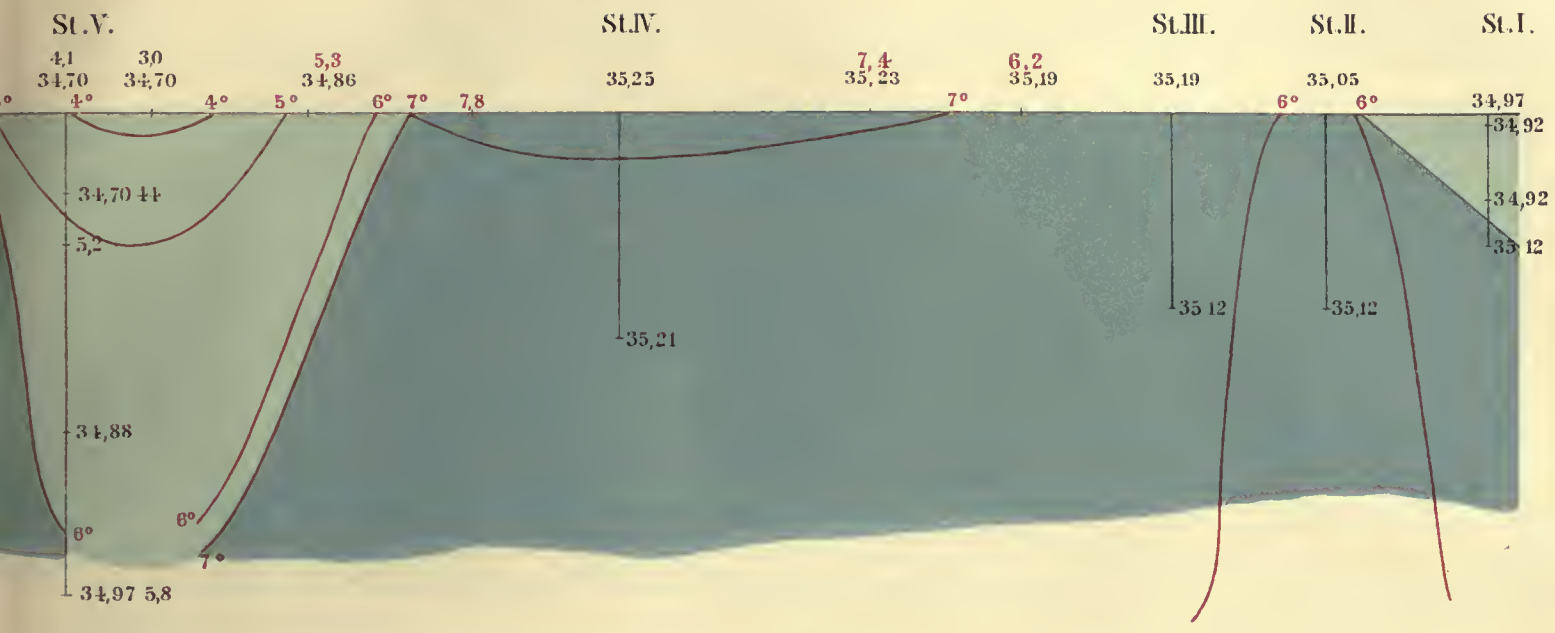


Fig. 1.

at various depths.

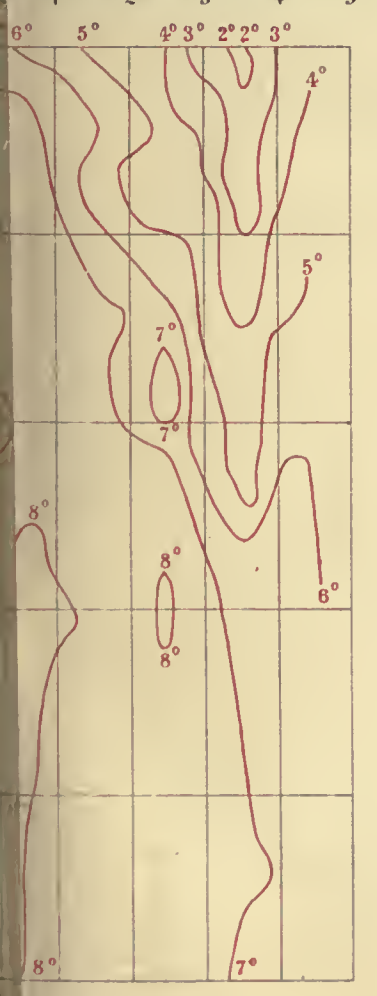
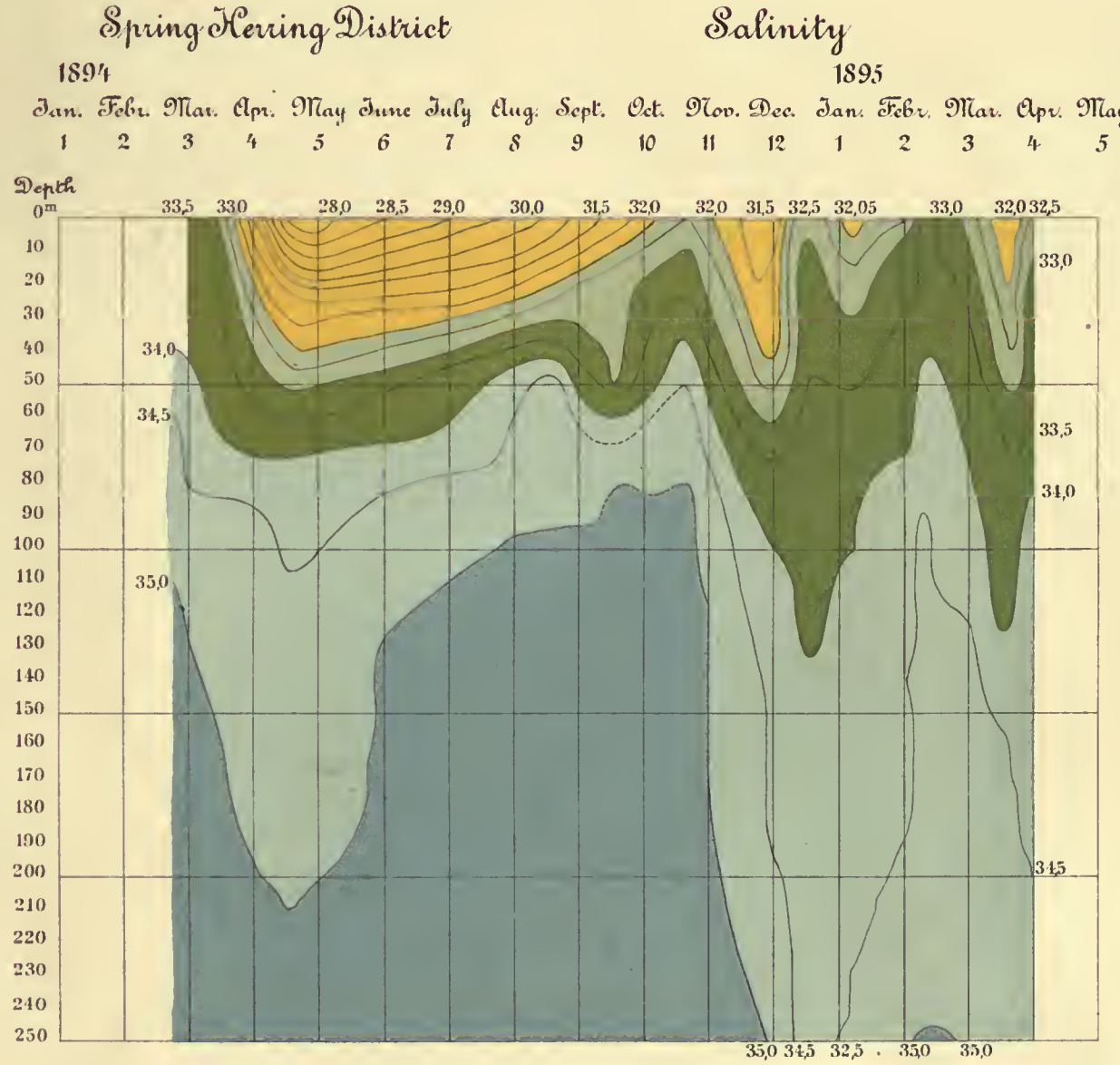


Fig. 4.

Spring Herring District Salinity



Lith. Anst. Julius Klinkhardt, Leipzig.

PLATE 6.

Figs. 1—4. Sections off the Norwegian Coast in Summer and Winter.

1 a. Off Hvidingsö, near Stavanger, Summer. Hydrog. Tab. A. I, Sts. 1—3.

1 b. The same locality during Winter. Hydrog. Tab. B. I, Sts. 179—182.

2 a, b. Off Marstenen, near Bergen. Hydrog. Tabs. A. I, Sts. 4—6, and B. I, Sts. 183—185.

3 a, b. Off Christianssund. Hydrog. Tabs. A. I, Sts. 7—10, and B. I, Sts. 186—188.

4 a, b. Off Vigten. Hydrog. Tabs. A. I, Sts. 11—13, and B. I, Sts. 189—191.

Fig. 5. See Hydrog. Tab. A. IV, Sts. 81—83.

The Reef — Norwegian Channel — Hvidingsö

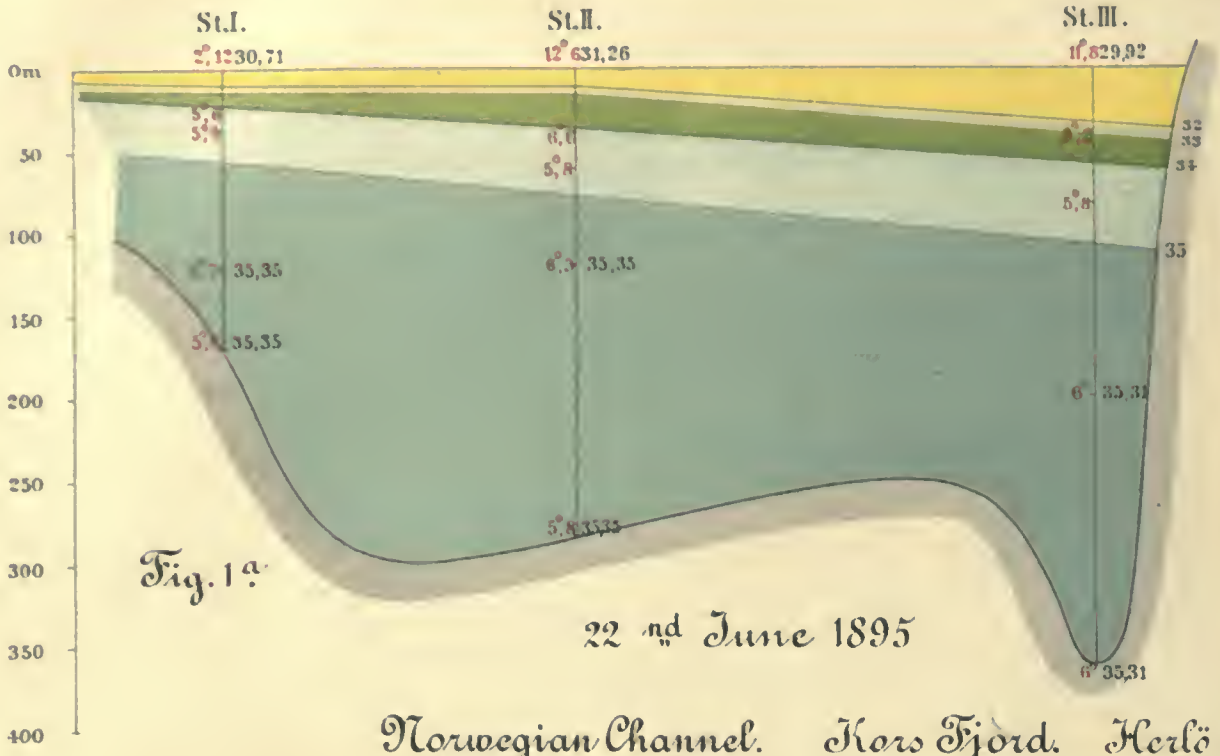


Fig. 1a

22 nd June 1895

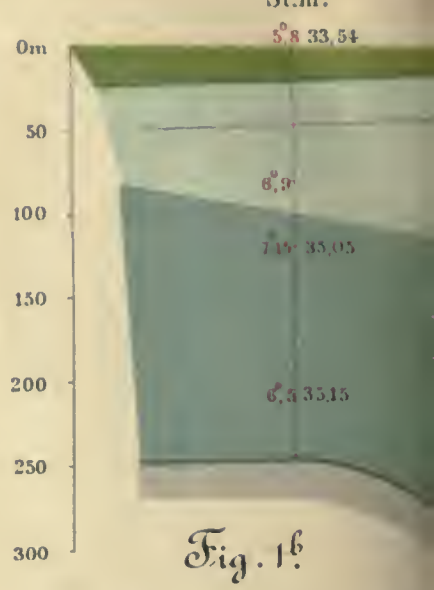


Fig. 1b

7 - 9 th February 189

Norwegian Channel. — Kors Fjord. — Herlö Fjord.

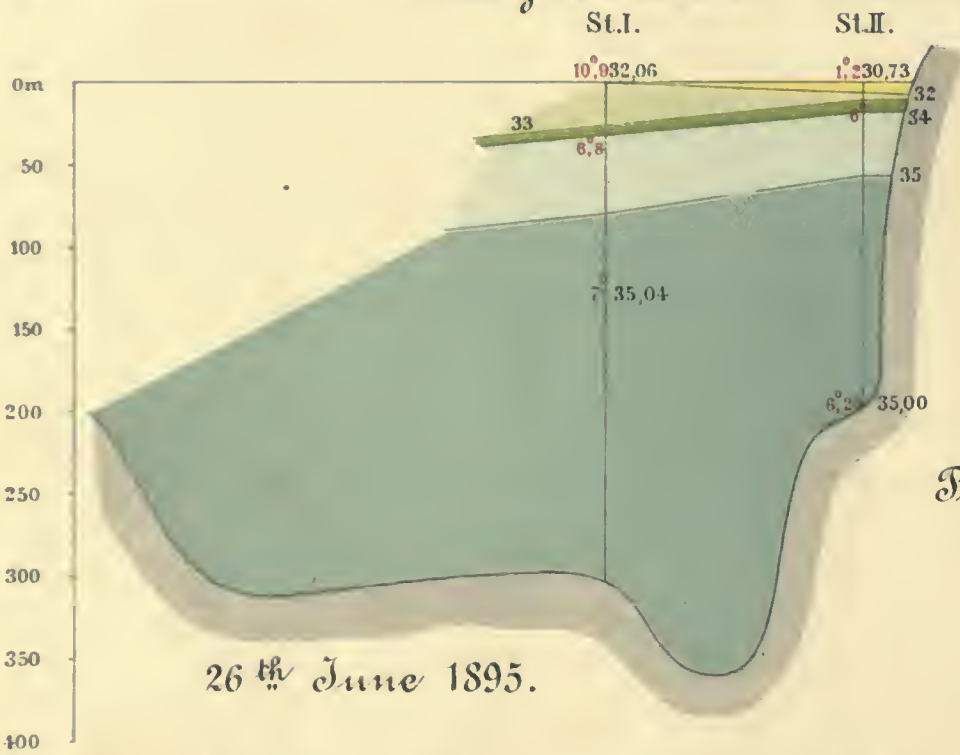
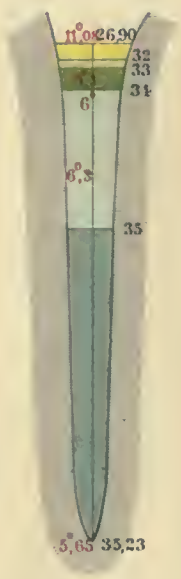
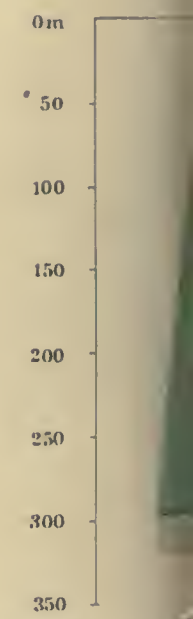


Fig. 2a



26 th June 1895.

27 th June.



14 th -15 th

Hallen-Bank. — Gjæslingen. Lighthouse.

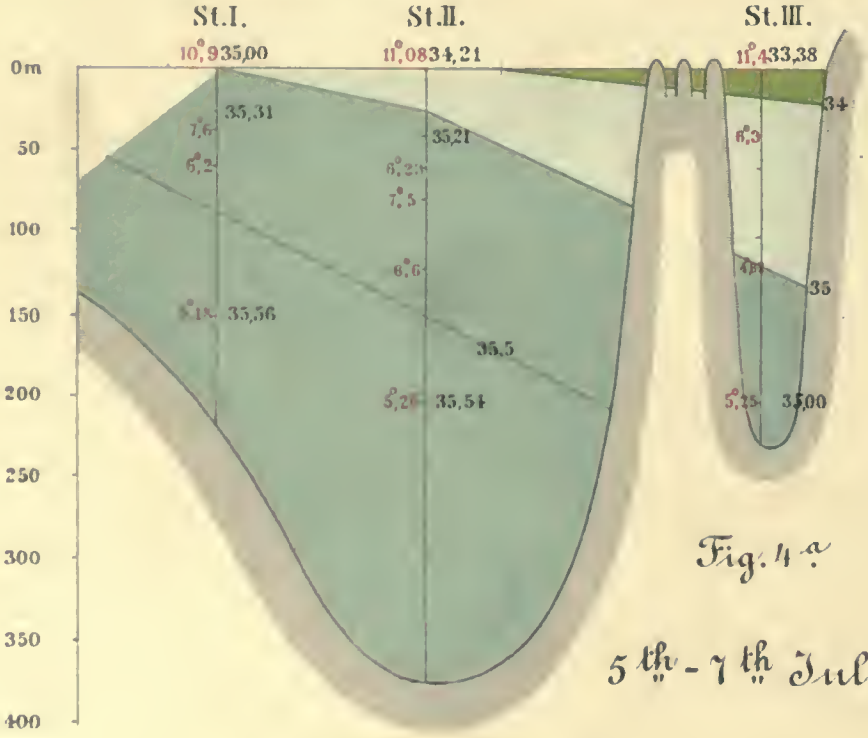
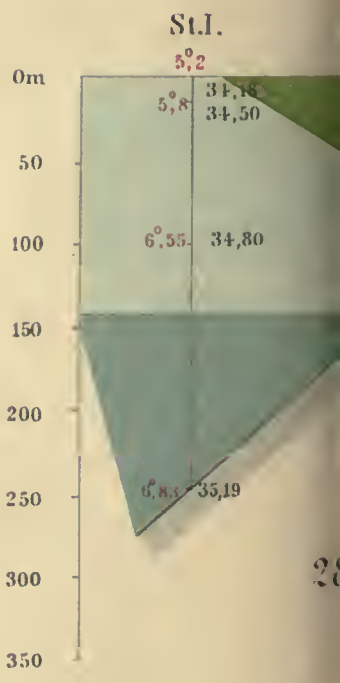


Fig. 4a

5 th - 7 th July 1895.



2

Hvidingsö.

St.II.

6°33,63

34

6°

34,93

35

35,15

Storeggen.

St.I. St.II. St.III. St.IV.

10°,9 34,12 11°,2 34,21 11°,55 33,88 11°,95 33,62

0m 50 100 150 200 250 300 350 400

5°,96 8°,25 5°,85 5°,8

6°,16 4°,9 34

7°,5 7°,4 5°,86 35

35,5 6°,86 5°,9 35,30 35,5

6°,12 35 64 6°,72 35,59

6°,12 35,64 6°,7 35,59

Fig. 3a.

Near Kristiansund.

2nd July 1895.

Kristiansund.

St.I. St.II. St.III.

5°,5 34,28 5°,6 34,16 4°,6 33,06

0m 50 100 150 200 250 300 350

6°,15 34,61 5° 34

5°,85

5°,8 34,38

7° 34,88

7°,1 35,12 35

Fig. 3b.

22nd February 1896.

St.II. St.III.

5°,62 34,13 4°,5 28,13

6°,1 34

35

7°,16

7°,35 35,05

7°,2 35,15 7°,25 35,05

Fig. 2b.

Marstenen.

uary 1896.

St.III. Gjæslingene.

4°,2 33,26

5°

34

b

February 1896.

St.XI. St.X. St.IX.

14°,3 33,11 19°,32 11°,19

0m 50 100 150 200 250 300 350 400

7°,1 33,18 6°,9 32

6°,9 34,53 34 34

34,40

34,71 34,71 34,41

7°,1 34,81 7°,2 34,81 7°,15 34,81

7°,2 35

35

7°,25 35,01 7°,5 35,01 7°,2 35,01

Fig. 5.

17th June 1896. 17 June 1896.

Trondhjem Sound. Trondhjem Fjord.

Lith. Anst. Julius Klinkhardt, Leipzig.

PLATE 7.

Fig. 1. Section across the Vest Fjord, and off Røst.

1 a. Summer (Hydrog. Tab. A. I, Sts. 14—19).

1 b. Winter (Hydrog. Tab. B. I, Sts. 192—198).

— *2.* Square Section of the Vest Fjord (Bodö—Moskenæs), August 1895. (Hydrog. Tab. A. II, Sts. 24 - 26).

— *3—7.* Observations in Nordland (Hydrog. Tab. A. II).

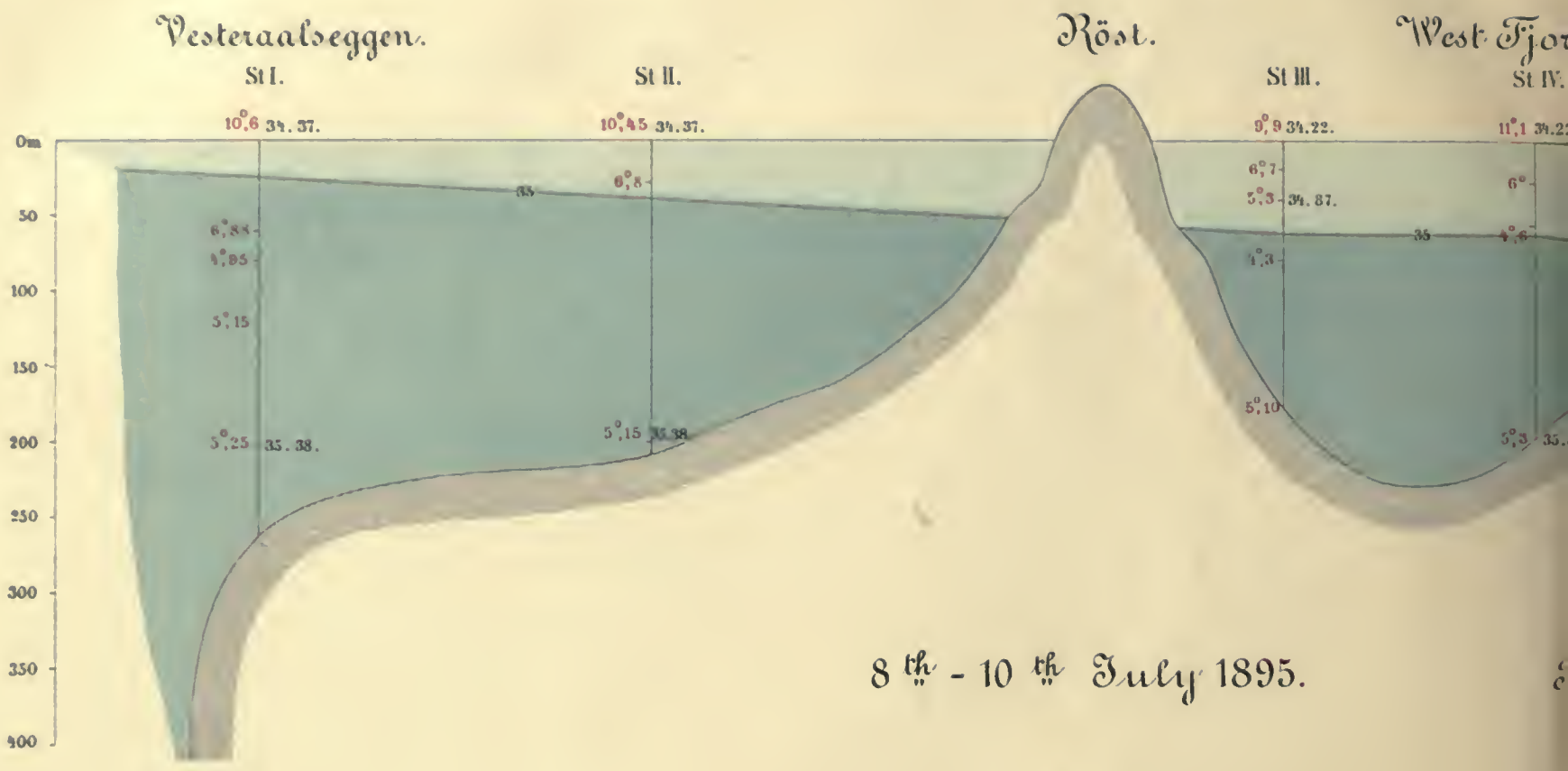
3. Sts. 21—22.

4. St. 20.

5. St. 32.

6. Sts. 27—29.

7. St. 30.



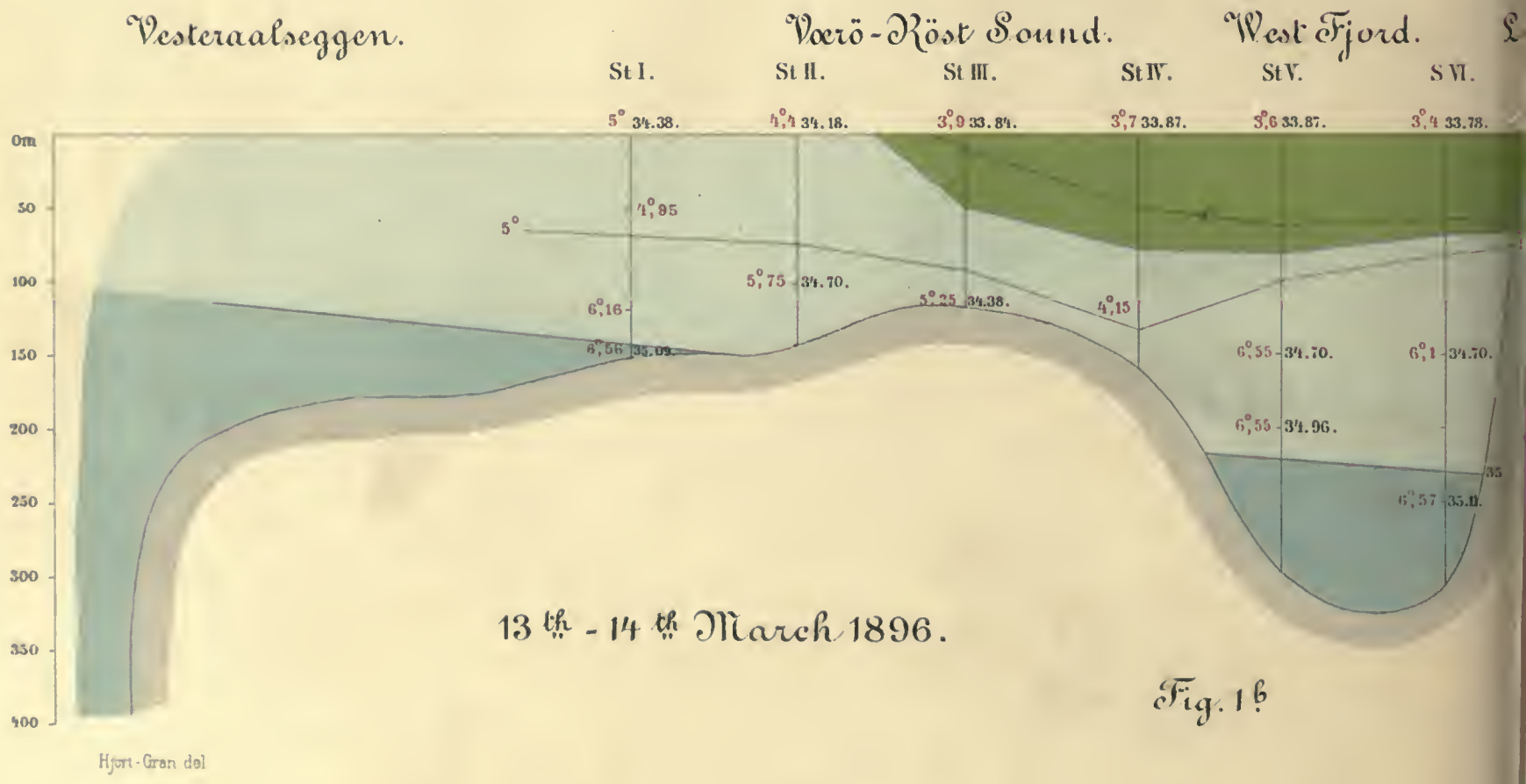
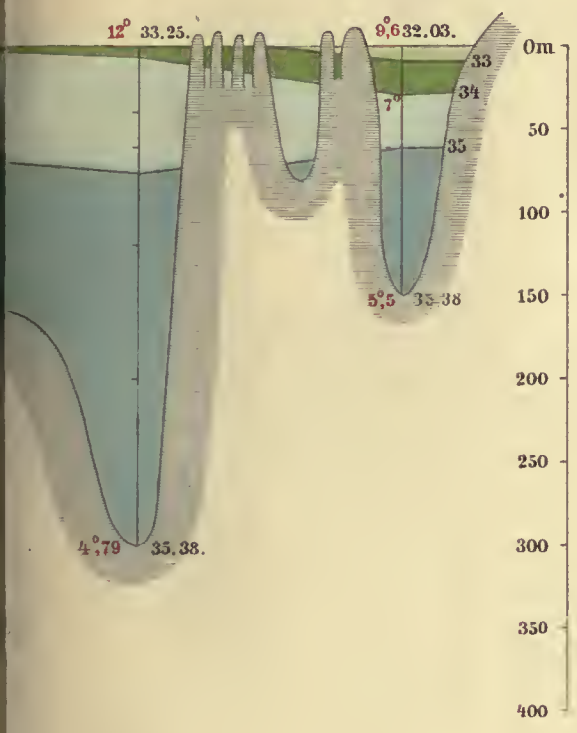


Fig. 1b

Hjort-Gran del

Bodö. Salten. Mosteenæs. West Fjord. Landegode. Bodö.

St V. St VI. St III. St II. St I.



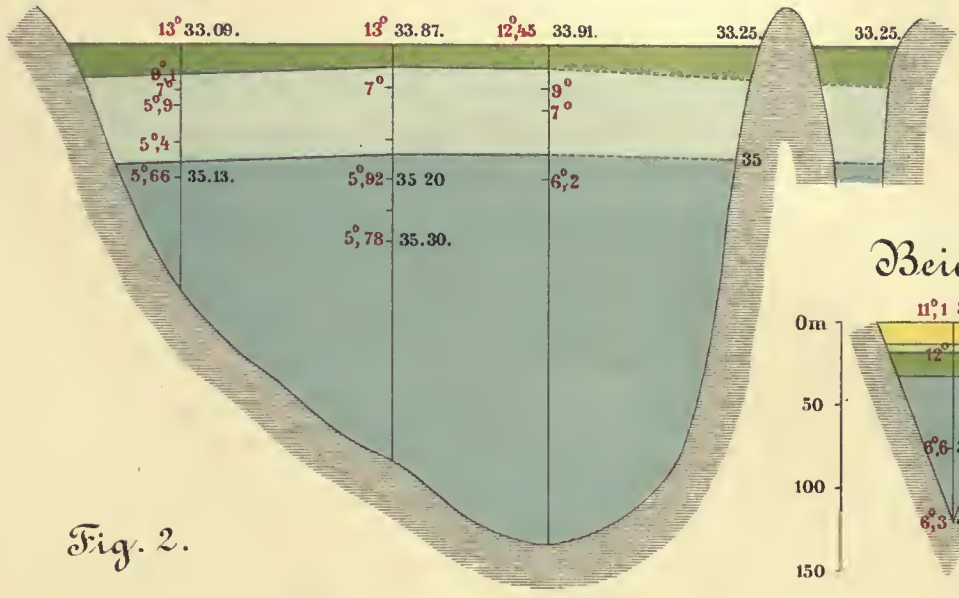


Fig. 2.

3rd August 1895.

Beieren.

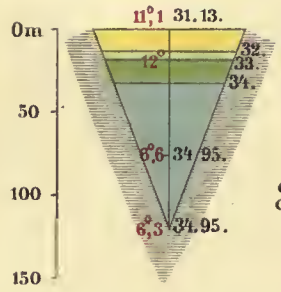
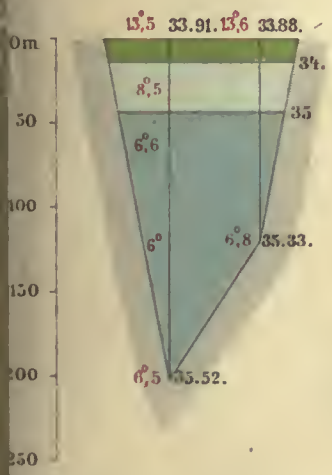


Fig. 5.

24th August.

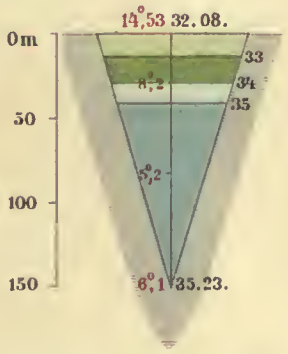
Fishing Villages near Bodö. Höla (Lofoten) Herö (Nordland) The Fjord Alsten-Dönnæs.

St I. St II. St III.



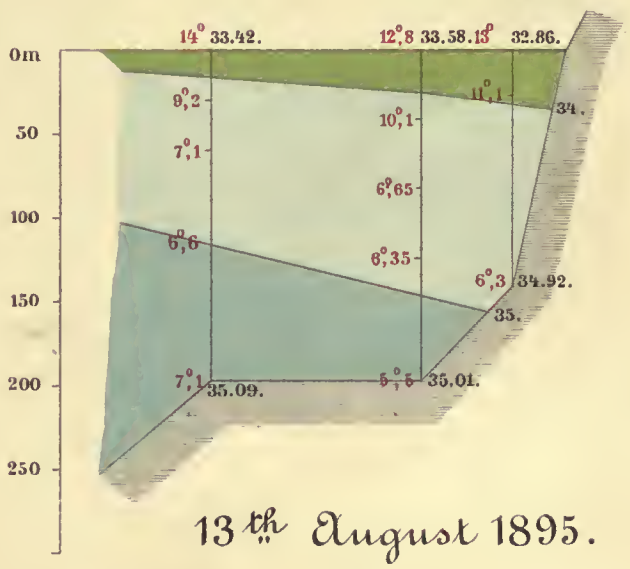
30th July 1895.

Fig. 3.



20th July 1895.

Fig. 4.



13th August 1895.

Fig. 6.

18th August. 1895.

Fig. 7.

Lith. Anst. Julius Klinkhardt, Leipzig.

CONTRIBUTION

TO

THE STUDY

OF

HYDROGRAPHY AND BIOLOGY

ON

THE COAST OF NORWAY

BY

O. NORDGAARD

WITH 1 PLATE

CONTENTS.

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C. Biological Investigations:

a) Observations concerning fishes, especially cod *(gadus callarius,* Linn.) ..... - 12

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PREFACE.

In the years 1896 and 1897 I have at the expense of the Bergen Museum undertaken hydrographical and biological investigations during the great season fisheries in the Lofoten district. From February to April 1896 sections were taken at several parts of the coast from Stavanger to Værö, as well as observations at the fishing stations of Lofoten. In captain Bie I had a very able assistant. The following year I worked alone, the investigations being limited to the banks of Lofoten, the outer side of the islands, Vesteraalen, and the Ofoten-fjord. The hydrographical tables provided by my expeditions were, according to a previous agreement, handed over to Messrs. dr. Johan Hjort and cand. Gran, so as to enter, as contributions, into the description to be given by these gentlemen of the currents of Norwegian waters. Mr. Gran has further defined and described the diatomacea and peridinea contained in the plancton samples collected by me. I have myself tried to give a description of the more important animal forms in the plancton.

On the following pages I intend to give an account of my work in the service of the national exploration of the sea. I admit at once that the results are not great, but at the same time wish it to be remembered that researches of this kind, to the north of the arctic circle, during the severest season of the year, in fishermen's boats, saving-boats, and small steamers, are undertaken under circumstances that greatly differ from the calmness and snug comfort of the laboratory. Generally speaking, natural exploration under such circumstances is of a nature to require as much from one's stomach as from one's mind.

I have to thank the gentlemen that have in different ways assisted me in this work. In the first place the authorities of the Bergen Museum, who have started me by providing money. Then I thank professors Collett and Sars, dr. Appellöf, curator Grieg, dr. Hjort, cand. Gran, dr. Klær, curator Bidenkap, and cand. Östergren of Upsala, for the valuable assistance given me in defining materials of several kinds. Especial thanks I owe to professor Sars, who has not only defined several crustacea taken from the stomachs of cods, but has also introduced me to a knowledge of the general forms of animal plancton.

A. General Remarks on the Lofoten Fisheries.

For many centuries Norwegians have gone to the Lofoten islands in order to fish cod. At several places in the old sagas accounts are found showing that the winter fisheries have been of great importance during all the time that Norway has existed as a united kingdom. In the past, as well as at present, the cod fishery of Lofoten has given a certain harvest every year, though the amount of the catch has varied very much. The fact that the Lofoten has from ancient times been known as the place where men could most surely harvest from the riches of the sea, can probably be adduced to a plurality of circumstances. The Lofoten fishery is a "gaat-fishery", i. e. the arrival of the ocean cod within reach of the several catching gear (sink-line, set-line, nets, &c.) is originated by the powerful impulse of propagation, which, supported by a remarkable instinct, causes large masses of sexually ripe individuals of cod to move in upon the coast banks. There is certainly reason to think that during the spawning time the cod does not deny its nature and despises the claims of its stomach, but still the real thing seems to be that during the spawning time the feeding question becomes one of secondary importance. It is also well known that the Finmarken "lodde-fishery" is more variable than the Lofoten fishery, a fact evidently caused by the circumstance that the migration of the cod shoals in the latter case depends on the presence of the "lodde" *(mallotus villosus)*. The chief cause of the favourable results of the long-established Lofoten fisheries is certainly to be looked for in the construction of the ocean bottom. By the soundings of the government chartographers and of the Norwegian North-Ocean Expedition, a good survey has been obtained of the bottom of the ocean; thus the existence has been proved of considerable bank plateaux outside the chief districts for the cod fisheries. Especially that of Lofoten is surrounded by vast banks, which the North-Ocean Expedition could follow all the way up to Spitsbergen. The circumstance that the water has a motion that makes it wash against the edge of the banks and thus causes a stowing up of the planctonic food material, is most probably an essential condition for the rich development of benthos forms of which the above mentioned Norwegian expedition has given sufficient evidence. Prof. Sars says in the report of the expedition of 1877: "Outside the district of Aalesund stretches the bank-edge Storeggen, already known and used for bank fishing in older days; outside the Lofoten district however lies, as we have been able to show, an edge of perfectly like condition. But in the same relation, in which the Lofoten fisheries surpass the Aalesund fisheries in importance, in the same relation the now discovered Lofoten edge has an extent as much larger than that of Storeggen. On this extensive edge, which stretches along the whole of the long island group of Lofoten and further northward, as well as in the coast sea lying inside of it, there is no lack of room even for such enormous masses of fish as those appearing during the Lofoten winter fisheries."

There are many reasons to believe that Mr. Sars is right in describing this edge as the real hunting ground of the ocean cod. Among other things may be mentioned that the hoe-fish hunters report that this rapacious preying fish particularly sticks to the edge mentioned. It is another thing that the fishing here can hardly be carried on owing to the strong current. That also cod and other bottom fish, as ling, haddock, torsk, halibut, exist on the extensive plateau inside the edge, has been proved by the bank fishers. For that the "*bank-cod*" is nothing but the Lofoten "*skrei*" has been made evident by the examinations of Mr. Sars. The reason that the ocean cod in the summer is more sparely caught by the fishermen, has probably to be sought in the circumstance that it then moves more thinly spread. A crowding-together of the cod may however also occur in the summer time, viz. under circumstances when some "aate" (food matter) appears in great quantity. Rich catches of summer cod have thus been made occasionally at Spitsbergen, as far north as the 80-th degree lat. Mr. Sars in his report for 1878 statest hat the North Ocean Expedition near Beeren Eiland fell in with large shoals of cod, which were gorging in fly-aate *(limacina helicina)*. During that same summer large catches were also made at Norsk-øerne in shallow waters (16—18 fathoms). Here too the *limacina* proved to form a main part of the contents of the fish-stomach. Such a fishery, however, must be varying, just because it depends on a plancton organism that is very irregular in its occurrence. In 1883 the summer fishing at Spitsbergen failed completely, and since that time scarcely any trial worth mentioning has been made.

Also in Western Norway there occur during the first months of the year arrivals of ripe cod, at least as far south as the reef of Jæderen. The fishing of the ocean cod coming up to the coast here, thus coincides as to time and place with the spring herring fisheries. The last mentioned cod fishery however does not in importance come near to the Lofoten and Söndmöre fisheries. The Lofoten fishery is by far number one, then follows that of Söndmöre as no. 2, and that of the "West land" as no. 3. Even at places lying between those mentioned, ocean cod is also being fished, but, as far as has been hitherto ascertained, the amount of fish is not so large as on the Lofoten and Söndmöre banks, although for instance on the Vigten banks and in the district Vesteraalen—Söröen it is by no means unimportant. In these places however the fishing sometimes fails.

On a chart of Norwegian waters showing depth curves of the sea bottom, will be seen that the edge of the ocean banks, in making a considerable bend inwards, formally points towards the West-fjord; that thereby the chief direction of the movement of the fish towards the coast is given, is considered to be affirmed by the experience of many years. It is therefore not very likely that the cod living along the great edge should, when the propagating time approaches, take the direct course on the Lofoten; the fish will follow the edge as it runs on, and that the stream of fish will then be directed into the West-fjord is thereby given.

Professor Helland*) says about this: "If the ocean cod, which we know is a bottom fish, on its way to its spawning grounds has no other guidance for its submarine navigation than the configuration of the bottom, while the fish is following a depth suitable for it, then the conclusion is obvious that the Lofoten fisheries must be annually constant, because the present configuration of the bottom has been essentially unchanged during the time known to history."

About the chief direction of the inward migration of the cod there have, however, prevailed different opinions.

Thus the renowned German geologist Leopold von Buch supposed that the cod entered through the Gimsöström and the Raftsund, and an older Norwegian author, amtmand Blom, thought that the wide channel between Værö and Röst was the great entrance gate.

*) Lofoten og Vesteraalen, p. 126.

It is well known that no cod fishing worth mentioning takes place on the continental side of the Vestfjord. A reason for this is easily found. Between the coast line and the edge there is here only an extremely narrow band, and the edge consequently very abruptly sinks towards the bottom of the Vestfjord. In other words, the bank plateau is here so small, that it does not afford suitable fishing grounds. It is however likely too that there are no such masses of fish along the inner edge as along the Lofoten edge proper. There is reason to believe that the greater part of the cod shoals that visit Lofoten start from the edge and bank plateau situated to the north of Lofoten, and these shoals will, by following the ocean edge, at last be directed to the fjord edge on the inside of the Lofoten islands. Thus it is but little probable that large masses of the fish coming from the north should pass across to the continental edge of the fjord.

On the other hand the bank plateau to the south of Lofoten is not of such extent as that to the north, and can consequently not support corresponding numbers of fish; besides, the cod fishing that takes place on the coast of Helgeland shows that the cod living more to the south choose more southerly ways for migrating to the coast banks. In other words, it is likely that but a very small part of the cod living to the south of Lofoten seek northward in order to perform its spawning.

The fish that have spawned in Lofoten, and escaped the fishermen there, seem also to return northward. Among other things that go to show this, is the circumstance that the late fishing that occurs (the so-called "skraapfiske") is most successfully carried on off Vesteraalen (for instance at Gaukværö).

It is however a fortunate fact that the Lofoten fisheries have been rather constant, season after season for centuries, which can be explained by a considerable stability in the natural relations that determine their course. It is no easy matter to point out the positive and negative causes and the extent of their operation, but in our searching for causes we shall at least find two prominent ones, viz. the immense surrounding banks and their great power of producing food for the fish. The ancient glaciers have scoured our country, so it is less fit for agriculture; in return the same glaciers have, by their contributions to the making of our ocean banks, given some compensation for what spoil they have taken from the land.

B. Hydrographical Investigations.

The importance of physical observations during the fisheries in Lofoten was argued by professor Sars already in his first report to the government in 1864, but not till 1878 temperature measurements were undertaken during the fishing season, by the then supervising chief, Mr. Juel. The observations were made in the harbour of Svolvær and at a distance of 1—3 geogr. miles SSE of Svolvær lighthouse. (See official report of 1878 p. 54—56). On February 25th, at the latter place, exceptionally high temperatures were measured, even up to 11°.5 C. at a depth of 60 fathoms; at the same time the bottom temperature (6 fathoms) in Svolvær harbour was above 4° C. Setting apart the 11°.5 C., it appears from the tables that the temperature at 60 fathoms has varied between 3°.75 and 7° C. During the two winters that I have undertaken measurements in Lofoten, I have nowhere found such a high temperature as 7° at a depth of 60 fathoms, so the temperature of the water strata in 1878 must have been higher than usually. Whether, however, this circumstance has influenced the fishing of that year, which by-the-bye was very rich, is likely to be doubtful.

Temperature measurements were continued in the following year 1879 at Svolvær (report 1879 p. 86—112). At the end of January and beginning of February the temperature of the air was on the average below zero (lowest temp. — 9°.4 C. on Feb. 4th). The measurements close outside Svolvær harbour also show very low temperatures in the upper layers of the sea, from 7th to 19th Feb. 0° to — 0°.75 C. being noted for the surface. The low temperature of the air, however, does not appear to have influenced very much the surface temperature of the fishing-sea close to Svolvær. Otherwise in the upper water strata, indeed even at the usual fishing depths of 40, 50, 60 fathoms, there have been great changes of temperature. Only at a depth of 70 fathoms it remains, nearly without exception, between 6° and 7° C. (31st Jan. to 10th April). The observations were continued at Lödingen in May and June by the direction of telegraph inspector Lie. Whereas the previous observations had throughout given the surface water as the coldest, the measurements of Mr. Lie show a displacement of the minimum to a few fathoms below the surface. The surface temperature in the month of May remains between 3° and 6°.2 C. and thus does not reach that of the bottom water. At a depth of 70—100 fathoms the temperature for May and June is between 6° and 7°, and at the bottom (100 f.) the variations do not exceed 0°.3 C. (6.°2—6°.5). Thus, while the temperature minimum, earlier in the year, lay in the surface, it is towards the middle of May displaced to a few fathoms below the same. Gradually the minimum sinks lower, so about June 26th it is at about 30 fathoms, when the surface temperature has risen above the comparatively constant bottom temperature by more than 2° C.

The measurement on June 26th 1879 gave the following results:

0	fathoms	9° C.
10	—	7°.2 -
20	—	6°.0 -
30	—	5°.4 -
40	—	5°.6 -
50	—	6°.0 -
70	—	6°.4 -
100	—	6°.5 -

In the same year 1879 at the fishing station Skraaven some series of observations were taken, which I here print complete as they appear to me to be characteristic.

Skraaven in Lofoten:

Depth		$^{26}/_{2}$	$^{7}/_{3}$	$^{2}/_{4}$	$^{3}/_{4}$
0	fathoms	1°.75 C.	3°.00 C.	1°.75 C.	1°.75 C.
10	—	1°.75 -	3°.00 -	1°.75 -	1°.75 -
20	—				
25	—	1°.75 -	3°.00 -	2°.15 -	1°.75 -
30	—	1°.75 -	3°.00 -	2°.15 -	
35	—	5°.00 -	3°.00 -	2°.15 -	
40	—	5°.50 -	5°.00 -	4°.00 -	2°.50 -
45	—		6°.00 -	4°.00 -	
50	—	6°.00 -	6°.00 -	4°.00 -	3°.50 -
55	—			5°.00 -	4°.00 -
60	—	7°.00 -	6°.25 -	6°.00 -	6°.00 -
70	—	6°.75 -	6°.75 -	6°.50 -	6°.50 -
80	—				
90	—	6°.50 -	6°.75 -	6°.75 -	6°.75 -
100	—				
120	—	7°.00 -	7°.00 -	7°.00 -	7°.00 -
160	—	7°.00 -	7°.00 -	7°.00 -	7°.00 -
180	—	6°.75 -	7°.00 -	7°.00 -	7°.00 -
190	—	6°.75 -	7°.00 -	7°.00 -	7°.00 -

The then supervising chief, Mr. Juel, maintains that the influence of the air temperature on that of the water neither seems to be very great nor to extend far down. This is of course to be thus understood, that a sinking of the air temperature for a shorter time does not cause a corresponding sinking of the temperature degree of the water layers. The old assertion that the cold should exercise an unfavourable influence on the fishing by lowering the temperature of the water, is thus deprived of any support. The incorrectness of the assertion must also be said to be proved by experience.

At that time, however, people began getting a strong belief in the influence of the sea temperature on the progress of the fishing. The measurements already undertaken had sufficiently shown that the temperatures in the usual fishing depths were extremely changing. Experience had also proved that in one case floating gear ("flöit-redskab") made the best catches, while in another case bottom gear was most successful. It was therefore an obvious conclusion to attribute these anomalies to the various temperatures of the water strata. I will later on enter upon a closer examination of this question.

The Lofoten report for 1880 contains a complete account of the measurements of inspector Lie at Lödingen from May to December 1879 (p. 94—98). It appears from the latter that the surface temperature reaches its greatest values in the month of August (9°.3 C.—14°.8 C.). The average of the surface temperatures observed during this month is 12°.6 C. In September the surface temp. remains between 10° and 11° with an average of 10°.8, and the temp. is sinking from the surface towards the bottom. In the month of October the sea enters into its autumn condition with a temperature maximum below the surface, and, at the same time as this in the course of the autumn is lowered in positive degree, it is depressed at the greater depths until at last, in value and situation, it coincides with the zone that seems untouched by the changes caused by the seasons. The upper limit of this zone may be put at a depth of 100 fathoms, or a little more.

On the basis of Mr. Lie's measurements, as well as the temperature media computed by Mr. Kokk for every half month for the observation station at Lödingen (report of 1880, p. 100—101), I will shortly sketch the annual changes of the temperature of the water strata. It will then appear whether later observations have affirmed the main features of this account.

In the four first months of the year the surface is the seat of the temperature minimum, but in May the latter is displaced to a few fathoms below the surface. According as the heat of the sun influences the upper layers, this minimum becomes more prominent and is at the same time pressed lower down.

Thus, according to the observations mentioned above, the temperature average for the first half of August is

at	0	fathoms	14°.7	C.
-	50	—	6°.0	-
-	100	— (bottom)	6°.5	-

In the first half of September the temperature medium is

at	0	fathoms	10°.7	C.
-	70	—	6°.1	-
-	100	—	6°.4	-

In the course of the autumn the surface is much cooled down, and in October the temperature consequently increases down through the layers towards a maximal value, and then sinks again. The autumn maximum has a similar movement as the minimum in the spring, it is pressed deeper and deeper until it is lost or turns into the zone that seems untouched by the annual changes. The measurements show that the autumn condition, which is thus characterized by a temperature maximum at a certain depth, lasts to the end of the year, while already the first half of January presents itself with the typical winter condition, i. e. with a minimum in the surface and a temperature rising downwards to 100 fathoms.

The other tables in the report of 1880 show temperature conditions in various parts of the Lofoten fishing sea, accompanied by observations on the progress of the fishing. At one and the same place the changes of temperature may occur rather quickly, but the general rule is however that it is lowest in the surface and rises towards the bottom. As a result of the whole of the observations, the supervising chief emphasizes that good fishing, partly even rich, has occurred in depths where the temperature has varied from 2° to 5° C.

The Lofoten report of 1881 contains an account of continued measurements at Lödingen (p. 179—182), as well as the computations by Mr. Kokk of the mean water temperature at the same place for each half month from May 1880 to January 1881 (p. 184—185). The results stated confirm my above given account. May and October are months of transition, and the bottom temperature at 100 fathoms varies, during all the changes in the overlying strata, only between 6°.3 and 6°.5. The highest temperature average falls on August with 12°.1 for the first half of the month, and 11°.5 for the second.

The Lofoten reports for 1881 also contain accounts of several measurements made at the fishing stations (Svolvær, Östnes-fjord, Raftsund, and other places). The experience made at the Östnes fjord seemed to indicate a certain connection between the water temperature and the fishing. In 1882 a rich fishing took place in the Östnes-fjord. The chief of the supervision, Mr. Brodtkorb, says (Lofot rep. 1882 p. 77) that in less than 8 weeks more than 6 million cod was brought up from the sea. The measurements taken showed that the temperature at 60—80 fathoms varied in February and March between 5° and 6°. Quite commonly, however, "flöit-redskab" (floating tackle) was used, so that the fishing chiefly was done in water of 4°—5° C.

Also in 1883 measurements were undertaken in the Östnes fjord, but, although the temperature in February and March does not seem to have differed much from what it was in the corresponding months of the previous year, the fishing did not succeed.

In 1884 temperature series were taken in the Raftsund. The supervision chief, Mr. Knap, states that the best fishing was made at a depth of 40—50 fathoms, the temperature of the corresponding strata being 4°—5°. Still the nets were preferably used at 60 f., and at this depth the temperature was higher, nearly up to 6° C.

In 1885 and 86 measurements were undertaken off the fishing station Hopen. The first year 5° was reached at 30—40 f. by observations in February and March, and the fishing was very good.

On March 5th the following temperatures were noted:

At	0	fathoms	3°.0 C.
-	10	—	3°.1 -
-	20	—	4°.0 -
-	30	-	4°.5 -
-	50	—	5°.0 -
-	60	—	5°.4 -

In 1886 the fishing off Hopen was not a good one, while on the contrary it succeeded very well off Henningsvær. The temperature, from the surface to 50—60 f., was, from March 11th to April 3rd, rather unchanged in the fishing waters off Hopen. This is of interest, because many measurements from the previous year had shown a most unstable and very variable distribution of temperature.

The measurement on March 11th gives these results:

At	0	fathoms	2°.4 C.
-	10	—	2°.5 -
-	20	—	2°.5 -
-	30	—	2°.6 -
-	40	—	2°.8 -
-	50	—	3°.0 -

If we compare this table with the measurements of March 5th 1885 the difference is striking.

In 1887 no temperature measurements were undertaken by the supervision service, but Edvard Meisfjord, the captain of a fishing boat, employed a deep water thermometer in the execution of his profession, and thought it to have been of great service to him.

In that year appeared professor Mohn's well-known work "Depths, temperature, and currents of the North Ocean". Professor Mohn has here given a description of the natural condition of the whole of the North Ocean, based on the knowledge obtained by the Norwegian expeditions of 1876 to 1878. The work besides contains a great deal of information on the hydrography of the fishing banks and fjords. Several of these results are of special importance for the hydrography of the Vest fjord and the Lofoten banks, and I shall, at the end of the present chapter, mention some of the facts for comparison with my own measurements. In 1888 no measurements were made by the supervision, but Edvard Meisfjord went on constantly employing his thermometer, and was confirmed in the belief in its practical usefulness. The following year five boat-captains had thermometers, and all express the opinion that the cod was to be sought in water of 4—5° C.

The year 1890 seems to have shown special conditions for the fishing according to the report of the supervision chief, Mr. Knap. The cod at an early period migrated to the shores, pressing into fjords and bays. A good fishing could thus go on close to the shore at a depth of 5—10 fathoms. It is true that only a few measurements were taken, but these at any rate do not seem to indicate exceptional temperatures. Thus it does not appear that for instance the higher water strata have had a higher temperature than usualy.

In the years 1891—92 the government caused temperature measurements to be undertaken in Lofoten on a greater scale. They were made by marine lieutenant Gade, who published the results in "Temperaturmaalinger i Lofoten 1891—92, Kristiania 1894". The whole fishing sea of Lofoten was thus for the first time subjected to a systematic examination as to the occurring temperature conditions. In 1891 the lowest temperature (0°.5 C.) was measured in the surface of the Östnes-fjord, on March 16th, and the highest (6°.6 C.) at 75 fathoms on March 28th on the edge south of Skraaven. The temp. of 6° was usually reached at 75—100 f. The highest surface temp., 3°.6 C., was measured on Feb. 26th in the Raftsund. In 1892 the temperature conditions differed very much from those of the previous year. About the middle of January there was in Vestlofoten about 5° in the surface, and at the bottom of the bank, in several places 7° and more. Even in East Lofoten the surface temperature at the end of January was about 4°. In the course of February and March the temperature decreased in the surface strata, but the deeper strata constantly kept at about 7°. Temperatures of above 7° in winter have not been found in Lofoten, neither before nor afterwards; the conditions of the fishing sea must certainly have differed much from the usual ones. The comparative particulars of the progress of the fishing given by Mr. Gade show that the fishing went on without any difference in water of 4°—7° C.

In the years 1893—94 no observations were undertaken under government authority, but several boat-captains used the thermometer, and the belief in the usefulness of this instrument was kept alive.

By agreement between commodore Knap and dr. Hjort, samples of the sea water were taken in 1895 by the captain of the saving sloop "Liv" in the fishing sea off Henningsvær. Besides, Mr. Knap caused samples to be taken at several other places in East Lofoten. The result of this work is printed in dr. Hjort's book ("Hydrografisk-biologiske studier over norske fiskerier", p. 140—142). The temperatures given there show a normal character, and the saltness of the surface varies between 32.83 and 33.71 pro mille. The saltness is slowly increasing from the surface towards the bottom. 5° C. is reached at different depths, the saltness as a rule then exceeding 34 ‰. In the autumn of 1895 Mr. Hjort himself undertook an expedition to Lofoten (hydrogr. tables A. II.). In 1896 captain Bie and myself took 5 sections in the coast sea from Stavanger to Lofoten, after which we made observations in the Lofoten fishing sea, partly in saving sloops, partly in steamers. Besides water samples, plancton was also taken.

In the winter of 1897 I undertook alone observations in Lofoten, Vesteraalen, and Ofoten.

Professor Mohn has in his above mentioned work (l. c.) collected a great number of interesting facts about the seas that surround Norway. However, as it is not my task to give a general view of the hydrography of the North Ocean, I will from Mr. Mohn's work only quote what is most necessary for illustrating the local conditions in Lofoten. From the table at page 49 will be seen that the distribution of temperature on the edge off Lofoten presents itself thus

1877 June 29th. Lat. 68°3′, long. 9°53′ E.

0	metres	8°.2 C.
91	—	7°.1 -
183	—	6°.2 -
366	—	5°.3 -
549	—	3°.5 -
732	—	— 0°.5 -
914	—	— 1°.1 -
1083	—	— 1°.12 -

Not far from Röst the North Ocean Expedition measured on June 28th 1877. lat. 67°35′, long. 11°46′:

0	metres	8°.4 C.
18	—	7°.7 -
37	—	5°.3 -
55	—	4°.9 -
73	—	4°.4 -
91	—	4°.4 -
115	—	4°.5 -

At the mouth of the Vest-fjord was found on June 22nd 1877, in lat. 67°27′, long. 13°25′:

0	metres	7°.6 C.
18	—	6°.82 -
37	—	4°.73 -
55	—	4°.16 -
73	—	4°.03 -
91	—	3°.89 -
110	—	3°.78 -
128	—	3°.90 -
146	—	4°.0 -
183	—	4°.3 -
219	—	4°.6 -
256	—	5°.3 -

According to Mr. Mohn (l. c., p. 87) the following series was observed from the surveying ship "Hansteen" on August 21st 1885 at the mouth of the Vest-fjord:

Lat. 67°8′ N. Long. 13°4′ E.

0	metres	11°.9 C.
25	—	13°.3 -
50	—	10°.3 -
70	—	8°.2 -
150	—	7°.0 -
200	—	6°.7 -
Bottom 280	—	6°.7 -

From the deep basin of the innermost part of the Vest-fjord the expedition measured:

June 21st 1878, lat. 68°12′, long. 15°40′ E.

0	metres	10°.7 C.
18	—	8°.1 -
37	—	5°.7 -
73	—	4°.5 -
110	—	5°.1 -
146	—	5°.8 -
183	—	5°.9 -
366	—	6°.4 -
549	—	6°.5 -
624	—	6°.5 -

Besides the temperature measurements in summer taken by the North Ocean Expedition and the "Hansteen", we have also the observations of dr. Hjort from the summer and autumn 1895 (see hydrographical tables A. II.). The latter show a temperature of 6—7° at a depth of 200 m., with a saltness of about 35 ‰. The 35 pro mille water rises in the summer to a height of about 40 metres from the surface. As a remainder of the winter cold, a temperature minimum is found at a certain depth in this layer with a high degree of saltness. From the observations of dr. Hjort appears further that the 35-curve in the course of the autumn is again lowered, while the summer heat has spread down-wards, so that the deep layers late in the autumn are warmer than at any other season.

The temperature changes of the seasons take a somewhat different course on the banks and in the open sea from what they do in the fjords. For the Vest-fjord, in my opinion, the account that has been given for Lödingen is upon the whole correct. In professor Helland's work "Lofoten og Vesteraalen" the physical condition of the Lofoten sea in winter is thus characterized (p. 117):

"A. The 35- and 34-curves are lowered still more down than in the autumn.

B. The temperature at a considerable depth (about 200 m.) is as a rule 6°.5, sometimes 7°. Hence it decreases towards the surface. The degrees of warmth in the different years undergo great changes according as greater masses of colder or fresher water form a layer above the 6°—7° water. Therefore, the surface temperature in February—March varies from 5° to 0°, of which numerous instances are given by temperature measurements undertaken in Lofoten."

This description of the winter condition in its general features is sufficiently supported by observations.

When in the following I am going to treat of certain details of the Lofoten hydrography, I shall especially have in view the condition of the sea during the first months of the year, that is during the time that the great cod fisheries take place.

From my tables it will appear that in the two winters 1896—97 there was in the West-fjord at a depth of 200 m. a temperature of 6°—7° C. In most cases 6° were already reached at 150 m., when the temperature has been 6° or more, the saltness has been greater than 34.5 ‰. At 200 m. the saltness very much approached to 35 ‰. At the mouth of the Tjeldsund I thus found (24 Feb. 97, no. 486) 34.96 ‰ at 200 m., temperature being 6°.2. In the Ofoten-fjord (24 Feb. 97, no. 489) I measured at 300 m. a temperature of 6°.1, the saltness being afterwards determined at 35.02 ‰. From the surface to at least 100 m. the temperature kept at 2°, saltness varying from 33.54 to 33.61 ‰; the 6th degree being reached at 150 m. This leads to two essential conclusions, viz. that the ocean water exists even in the deep of the inner fjords in winter, and that the cold fjord-water may have a considerable volume. This circumstance is no doubt of great importance in regulating the temperature on the Lofoten banks, as during continuous land-wind the fresher and colder water is pressed out, from the fjords of the continent, and into the Vest fjord, whereby the temperature on the banks is lowered. That sea-winds have the opposite effect may be concluded a priori, and has several times been proved by experience.

Towards the mouth of the Vest-fjord and on the outer banks, no such sharp distinction will be found between a colder layer and a warmer one as was the case in the Ofoten-fjord, and has been proved several times to exist in the Vest-fjord, especially in East Lofoten. I have at wintertime on the outer Lofoten banks found that the water layers are very homogeneous. Most clearly this appeared at the measurements on the outside of Vesteraalen at the beginning of February 1897. Thus at one place, situated in lat. 68°50′ N., long. 14°36′.5 E., the temperature was found (8 Feb. 97) to be about 4° C. from surface to bottom (110 m.), and saltness to be 33°.80 ‰ (no. 472). Likewise was measured (10 Feb.) in lat. 68°51′.25. long. 14°31′ E., a temperature of 3°.9 —4°.35 C., respectively at surface and bottom (170 m.); further it will be seen that this layer had a saltness of 33.92 ‰, from bottom to a few metres below surface (no. 473). To such a thorough mixture scarcely any parallel will be found in any of the fjords. By observations at the outer and inner sides of Röst, it also appeared that a rather perfect mixture was completed. Thus I found (28 April 1897) at 4½ miles NW. of Röst a temperature of 4°.6 C. from surface to 100 m., and at the bottom (140 m.) 5° C., saltness varying between 34.11—34.67 ‰, respectively at surface and bottom (no. 538). On May 1st the same year, 4°.5 was measured in 0—100 m., the saltness being throughout the whole layer 34.18 ‰. At 150 m. a temperature of 4°.7 was observed, saltness 34.30 (no. 539). That the above figures were nothing particular for the year 1897, is shown by measurements on the outer banks in the previous year. In one place (lat. 67° 47′.5, long. 11°42′ E.) on April 4the rise of the temperature, in from 0—150 m., was 5°—6°.55, and the increase in saltness 34.38—35.09 (no. 193). At the latter place the ocean water was thus found at a depth of 150 m., but the overlying water layer presented gradual transitions to the 35 pro mille water. When the sections off Vigten and Kristiansund are considered, a similar condition will be seen to exist there. Generally speaking, it is characteristic of the winter condition on the Norwegian coast banks that the 33 pro mille water gradually mixes with that of 34, and the latter again with scarcely noticeable intervals mixes with that of 35. The isohalines for the three grades of saltness are gradually raised in proportion to the distance from the coast line, reaching the surface in the order of their numbers.

From my measurements of 1896—97 will be seen that the water that in winter has the greatest vertical extent on the inner fishing banks of Lofoten, has a saltness of between 33 and 34 pro mille. The temperature of this layer varies between 0° and 5° C. It will as a rule be found that when temperature has become 5°, the 34 pro mille are also exceeded. In my opinion, this water (33—34 ‰) on large stretches of the inner banks usually reaches the bottom. It rests upon a layer of 34—35 ‰ with temperature of 5°—7° C. Water of oceanic saltness (35 ‰ or more) does not in winter as a rule reach up upon the fishing banks in Lofoten, but is depressed to the deep trough of the fjord. No. 513 shows at 270 m. temp. 5°.4, saltness 34.96 ‰, and, as mentioned above, in the Ofoten-fjord I measured (Feb. 24th 1897) at 300 m. temp. 6°.1 C., saltness 35.02 ‰. During my temperature measurements in East Lofoten my attention was rather soon drawn to a sharp limit that often appeared between a colder layer and a warmer one. My measurements on Feb. 24th and 25th 1897 in the Ofoten-fjord (nos. 489, 490) show that the limit there is still more prominent. No. 489 shows a great homogeneity in the layer of 0—100 m., and at the next station (nearer to where the Ofoten-fjord opens into the Vest-fjord) the temperature variation in 0—120 m. is only 2°.0—2°.8 C., and the variation in saltness 33.54—33.73 ‰. At 150 m., however, 6°.0 C. and 34.96 ‰ are found. There is little reason to believe that the Ofoten-fjord differs from the other fjords that open out into the Vest-fjord; in other words these fjords contain a storage of cold water sufficient to make itself perceptible, especially in the East Lofoten fishing sea. It is also in East Lofoten that the measurements have shown the lowest temperatures in the surface layers. According to my experience, the surface temperature rises on the banks in a westerly direction, which also appears from the measurements of captain GADE in 1891—92. If to this we add the circumstance that in West Lofoten the boundary between the colder layer and the warmer one is more indistinct, these phenomena must be explained as the result of a more advanced process of mixture, which is most complete in the surface layers of the outer banks. It might then seem likely that the winds are of great importance as to the regulating of temperature on the Lofoten banks, and the influence of the winds might plainly be expressed thus: prevailing land winds drive the cold fjord water out upon the inner banks, while sea winds press the warmer water of the outer banks inwards towards Lofoten. The measurements of Mr. GADE in 1892 seem to me to give a characteristic instance of the inward movement of the outer bank-water. In the most westerly part of Lofoten Mr. GADE measured in January 5° at the surface in several places, and, supporting myself on my own observations, I suppose that the surface saltness has been above 34 pro mille. Already at a depth of 110—140 m. a temperature was reached in certain places of 7° C., to which has evidently corresponded water of oceanic saltness. This must be said to be exceptional, and it would be of great interest to know the working causes. Also in East Lofoten the 7 degrees water had in 1892 a high level. Thus it may be noticed that on the edge south of Skraaven (GADE's station III) 7° was measured at a depht of 110—140 m. in the course of Feb. and beginning of March. In March a small lowering occurred, so the bottom layer on the 28th had the temperature of 6°.7, to which, according to my observations, a saltness between 34.5—35.0 ‰ was to correspond. Mr. GADE, in his report to the government, mentions southerly winds causing currents to which certain temperature changes were attributed. It is however difficult to decide whether these southerly winds alone suffice to explain the exceptional condition of temperature in Lofoten during the winter of 1892. Mr. MOHN says (l. c., p. 96) that in winter the surface temperature is lowest near land, and increases further out towards the sea, as well as down towards the deep. At the same place (p. 97) the cause of this is clearly stated: "The temperature of the air at that season (winter) being lower than the temperature of the sea surface, and lower over the land than over the sea, we must obviously seek in the cold air over the land for the cause of so remarkable a distribution of the sea's temperature on the coast during

the winter." That the surface temperature in winter, at harbours or close to land generally, is lower than further out, has constantly been confirmed by experience. Even though the land be a comparatively small island, it has proved to be the case. Thus on March 13th 1896 the surface temperature in the Röstnes-Vaag (Værö) was 2°.2 C., while about 3 miles off land I measured 3°.4 C. As a rule, the saltness too is least near the land. I will give a few instances chosen at random:

February 25th 1897.

Liland harbour, Ofoten-fjord .	t. 0°.8 C.,	s. 33.06 ‰
Out at sea, off Liland.....	- 1°.6 -	- 33.30 —
At mouth of Ofoten-fjord	- 2°.4 -	- 33.30 —

March 18th—19th 1897.

Section across the Vest-fjord (Grötö—Svolvær).

At Grötö	t. 1°.2 C.,	s. 33.73 ‰
Six miles off Grötö.....	- 2°.7 -	- 33.91 —
In the middle of the Vest-fjord	- 2°.8 -	- 33.96 —
Höla, near Svolvær.....	- 2°.2 -	- 33.84 —

Thus it seems to be a rule that in winter temperature as well as saltness is highest along the middle of the fjord, a lowering taking place to either side. I have before mentioned that the water layers on the outer banks show a greater homogenousness in temperature and saltness than in the fjords and on the inner banks. Thus it has also been shown that in the harbours of the outer side of Vesteraalen the water is exactly of the same saltness as further out, while however the temperature is somewhat lower on account of the coldness of the land.

In a paper in the transactions of the Kristiania Videnskabsselskab for 1873. professor Mohn has discussed the effect of currents on the temperatures of the water and the air.

Mr. Mohn here emphasizes as the result of his own observations that the surface temperature in the streaming water of narrow channels is in summer lower than at neighbouring places where the waters are wider. It is also suggested that in winter the surface of streaming water is somewhat warmer than in places where the water is at rest, but that the difference is likely to be small. The author alleges many illustrating instances that the difference mentioned can be quite considerable, even as much as 3° C. The phenomenon is, according to Mr. Mohn, explained thereby that the colder water, on account of the streaming motion, is drawn up to the surface.

During my expedition in 1896, I made a few observations supporting Mr. Mohn's theory about the winter temperature in streams. Feb. 14th 1896 I measured off Kvarven near Bergen 3° in the surface, in the Vatleström south of Bergen 5°.4, further down in Vatleströmmen 5°, and in the Kors-fjord on the same day 4°.5 C. In the well known Mosken-ström that runs between Lofotodden and Værö, I have also perceived a small difference of temperature between the surface of the stream and the surrounding open sea (see hydr. tables no. 202—205.). With a little increase of temperature also follows a corresponding small increase of saltness. It is obvious that the increase of temperature in streams in winter is rather slight, just because the increase in temperature is quite trifling in the upper water layers.

The local conditions of the Lofoten streams are of no small importance during the fishing, as a strong current is a hindrance to the use of the fishing tackle. The current caused by the tide is very much differing in strength, and there are great irregularities in its direction. It often happens that the direction of the current near the Lofoten islands is quite opposite to what it is farther up the Vest-fjord. Thus for instance on March 26th 1896 I observed, 8 miles off Reine, a sharp boundary between a south-westerly current and an easterly one, the former of which was nearest to Lofoten. That this was no mere chance is proved by some statements I received from captain A. Sörensen of observations taken at Reine in April of the same year:

April 6th and 7th at 10 a.m. the current ran westwards about 8 miles off Reine, wind being SW.

April 8th, 12 noon, wind NW, near Lofoten an easterly current, 8 miles off Reine a westerly current.

April 9th, at 2 p.m., wind SE, near Lofoten easterly current, 6 miles off Reine westerly current.

April 10th, 2 p.m., wind SW, current conditions the same as on the previous day at 2 p.m.

April 11th, 4 p.m., wind NE, the current nearest Lofoten easterly, and about 8 miles off it was westerly.

This at any rate shows that the direction of the current close to the islands and farther up the Vest-fjord may differ for several consecutive days. It is most likely that this is the rule. My measurements on March 26th 1896 showed different surface temperatures at the two sides of the boundary of the currents, the temperature of the east-running current being 3°.6, and of the west-running one 3°.2 C. In saltness too there was a small difference (see hydr. tables, no. 219, 220).

I cannot well leave the present chapter without once more mentioning the much debated question of the dependence of the fishing upon the temperature of the sea.

From what has been said above it will have appeared that the temperature measurements of the first years seemed to lead to the conclusion that the use of the thermometer might be of practical service to the fisherman. It is however quite a common thing that at first too much importance is attached to the bearing of scientific discoveries upon practical life. People will see assistance and improvement where such are really not at hand. I therefore think that no great importance can be attached to the few statements we have from fishermen about the help obtained from the thermometer in their work. Nor can it be denied that 5 degrees as the best temperature for fishing has been made doubtful by the investigations of recent years. Mr. Gade, as before mentioned, found that good fishing was carried on in water of 4°, 5°, 6°, 7° C., and I have ascertained that about the middle of March 1897 there was good fishing on the banks from Henningsvær to Balstad in water of 3 degrees. In the month of March. when the chief fishing takes place, the thermometer can consequently be of no guidance to the fisherman because the scope is too great (3—7° C.).

A little cod-fishing I have also seen going on in water of 2 degrees (Östnes-fjord).

The fishermen state as a common experience that the cod at the beginning of the season most often keeps to the fjord edge in

rather deep water. The reason is supposed to be that the fish does not like to enter up into the colder water on the banks. There may be something true in this, but it is also possible that the stay of the fish on the edge for some time before spawning is caused by the circumstance that most food is found there. It has been supposed that the cod during the spawning time eats next to nothing. It is certainly true that a great number of the stomachs examined have been empty and contracted, but this may as much be caused by want of food as by want of appetite. Several circumstances, however, bear evidence that the cod eats even close before spawning, and it is therefore likely that it stays where most food animals are found, i. e. on the edge. When the spawning time approaches, the fish goes up on the banks to shed its roe and milt; it is then of course caught in more shallow water. That temperature has any essential influence on the migration from the edge to the spawning grounds, I do not think can be maintained, after the observations hitherto made. From the reports of the supervision chiefs it is clear that in some years large shoals of cod, already at the beginning of the fishing season, migrate into fjords and bays, where the fishing then takes place in comparatively shallow water. At the same time the existence is reported of some "aate", e. g. herrings or cuttlefish, and it seems undoubtful that the disturbance in the normal migration of the cod is caused by this "aate". But this also proves that food is of as much importance as temperature. Nor have we hitherto any observations to support the idea that the presence of "aate" in this case is owed to exceptional physical conditions of the upper layers; on the contrary the few temperature observations we have from such years do not at any rate testify to anything unusual.

At the present standing of the investigations, the opinion seems therefore most reasonable that the temperature of the water exercises little influence on the fishing in Lofoten. The year 1892 for instance gave a moderate produce, notwithstanding that the 5 degrees curve lay high up in the water.

Dr. N. Knipowitsch*) has published a list of fishes existing in the Murman Sea and the White Sea. According to this author the cod is very general in the White Sea: "Am häufigsten im Golfe von Kandalakscha, NW-Theil des Weissen Meeres." Great quantities occur at the Murman coast, where it is the object of large fisheries. The most easterly place on the said coast where cod-fishing is carried on on a large scale is Wostotschnaja Liza (Knipowitsch). Thus, generally speaking, it may be said that the White Sea forms the limit of the extension of the cod to the East. This is certainly not accidental. Mr. Knipowitsch (l. c., p. 155) notes the Murman coast as belonging to the warm area. The bottom temperature is nearly without exception above 0° C. during the warm season; there is little formation of ice in winter, and no drift ice. In the White Sea the summer temperatures in the upper layers are rather high, but during the long winter large masses of drift ice exist, and in the deeper layers the temperature in certain places is all the year round below 0° C. To the east of the White Sea the bottom temperature, even in the warmest months of the year, is below 0° C., and during the greater part of the year drift ice occurs in great masses. Temperature thus puts a limit to the horizontal distribution of the cod; it is exclusively confined to the warm area; the 0-point is not exceeded.

If this is applied directly on the conditions in Lofoten, it may at once be noted that the temperature on the usual fishing banks is never 0°, but as a rule 2—5 degrees above zero. So far, the temperature of the water should never be a hindrance to the fishing. Such a conclusion, however, must be made with a great deal of reserve. Allowing it to be it a fact that 0° C. is the lower limit to the accomodating power of the species, we dare not directly conclude that individuals usually living in water of 4°—6° C. would volunteer up into water the temperature of which greatly approaches the boundary that puts a limit to the horizontal distribution of the species. I do not think, however, that between the migrations of the cod and the physical conditions of the water layers exists that close connection that the investigations of recent years have ascertained in the case of the herring. An abundant occurrence of food animals certainly contributes far more to keeping the cod gathered in one place than the circumstance that the water is 5° C. Nor is it improbable that fluctuations in the fishing, partly at any rate, may be ascribed to changes in the amount of lower animals gathered on the banks. Bottom trawling in one and the same place, one year after another, has produced facts indicating that the fauna in some degree changes character. Our knowledge of these things, however, is very deficient.

*) Annuaire du musée zoologique de l'académie impériale des sciences de St.-Petersbourg. 1897, no. 2, p. 144—158.

C. Biological Investigations.

a. Observations concerning fishes, especially cod *(Gadus callarias,* Linn.).

Zoological investigations of the sea for a practical purpose may be said to date, in the case of our country from the year 1864, when professor Georg Ossian Sars started his observations during the Lofoten fisheries. Already the following year Sars made a discovery greatly calculated to create a sensation, when he proved that the spawn of the cod floats and goes through its development in the open sea. Because however the result was only published in the Norwegian language, this discovery did not attract the attention it deserved. In the years 1864—70 Mr. Sars was engaged in studies of the development of the cod-fry and other circumstances relating to the natural history of the cod, the chief results for each year being published in reports to the home department.

Mr. Sars divided the Lofoten fisheries in three phases, the immigration of the shoals on to the banks, the spawning period, and the emigration. The immigration may be said to commence with the month of January, and lasts to the middle of March, which is the actual spawning month for the masses of cod that migrate to Lofoten. The fishing that goes on in the month of April may be generally said to depend on the outgoing shoals. That the main mass of the cod spawn in March is certainly the rule, but this does not prevent the occurrence in the sea of cod-spawn at the end of February, which Sars emphasizes, and which I have had opportunities of confirming. Further it may also be mentioned in this connection that I have seen female cods having filled roe-bags at the beginning of May, though this is only exceptional. In the year 1865 Sars undertook artificial fecundation of cod. After 8 days the fetus could distinctly be seen, and in the course of 18 days the development of the embryo was finished. The experiments showed that only the roe that allowed of being pressed out of the fish by a gentle pressure, was fit for fecundation. Likewise it was proved that even roe of recently died fish retained the power of germination, and that roe having reached a certain stage of development was little susceptible of outward influences. Even if the sea water was considerably deteriorated, and the egg covered with fungoids, the development went on rather undisturbed. Even the recently slipped young ones could stand deteriorated water, but herein an immediate change occurred the moment the yolk-sac was absorbed. When the gill-splits were formed the young did not all survive coming into deteriorated water. Concerning the spawning itself, Sars remarks that the females stand at a higher level in the sea than the males, which depended on the circumstance that both roe and milt rose to the surface after being shed. Also, the micropyle through which the fecundation was performed turned downwards, and the development of the embryo took place at the lower pole. In the winter of 1865 Sars also proved that the haddock, as well as other species, shed floating spawn, and during a voyage in the following summer the mackerel too *(scomber scombrus)* was registered on the list of fishes whose spawn shares the fate of the planeton.

Throughout the years 1866—70 Sars applied himself with great vigour to the study of the biology of the cod, and his efforts were crowned with success. At the end of May 1866 he found that a great deal of cod fry had migrated into the bays and sounds on the east side of Skraaven. The length was then (May 20th) 7—8 mm., and they were swimming about in the surface of the water; the stomach contents were found to consist chiefly of calanides. About the 12th of June the planeton was very abundant, and the tiny fry were swimming vividly about, snapping after the small species of calanus. The largest specimen then had the length of 24 mm. Gradually the embryonal fin began dissolving into the dorsal and ventral fins, and in the largest individuals there were signs of the barbal thread in the form of a small knot at the point of the lower jaw. A period of bad weather for some time prevented the investigations, and when fair weather returned (June 23rd) it was only exceptional that cod fry was to be seen. After searching in vain for several days, Mr. Sars (5th July) at the fishing station of Brettesnes became aware of a very young fish jotting out from under a jelly-fish *(cyanea capillata)*. It proved to be a young cod, and by examining a greater number of jelly-fishes he found a great deal of young cods as well as haddocks. From under the disk of cyanea, as well as aurelia, young cods were frequently taken, the largest being about 40 mm. long and having 5—6 dark crossbands. In the stomach were found specimens of an amphipod *(hyperia)*, which leads a parasitical existence on the jelly-fishes. This circumstance seemed to suggest a reciprocal usefulness of the young fish and the jelly-fishes.

Tbe following year, 1867, young cods were also observed under tbe jelly-fishes towards the end of July. By later examining the stomach contents of large green-cods, tbese fisbes proved brimful of fry both of cod and green cod, but the contents were generally so dissolved, that a careful examination could not be undertaken. The young cods, however, thus obtained, were found to be larger than those that sought the protecting company of the jelly-fishes. The matter was now to seek for the haunts of the green cod; for where this fish stayed its food must also exist, and the latter, as already mentioned, consisted chiefly of young cods. As a curiosity may be mentioned tbat a live young cod, 80 mm. long, was taken from the stomach of a green cod.

During tbe continued pursuit of the young cods, Sars discovered (August 3rd) that a whole lot of them had taken refuge among floating bits of sea-weed and other objects driven together by the current. He succeeded in catching some of them. The length was 50—60 mm., with a fine colouring, a developed barbal tbread, and with the fins arranged as in the grown-up individuals. On August 23rd a rich catch was made of young cods, which now swarmed along the shore. The stomach contents consisted of crustacea, as *gammarus locusta,* annelides, &c. It further came to be seen that in the course of September young cods were found at different places along the shore, but the length of these continually kept at 60—70 mm. As there was no reason to believe that at tbat period there should be any hindrance to the growth, because in the belt of sea-weed there was sufficient food, Sars formed the opinion that it then was a period of immigration to. and an emigration from, the littoral region, which consequently only served as a temporary staying ground for the young cods. As the spawning does not occur contemporaneously, the migration to the sea-weed belt will be extended over a period that depends on the lasting of the spawning time.

By fishing experiments at the beginning of October, the older young cods (120—130 mm.) were found at a greater depth, and their age was put at about 7 months. In the following year, 1868, Sars caught at the beginning of December young cod whose size varied between 150—200 mm., at the depth of 8—12 fathoms, near Skraaven. These had their stomachs brimful of sea animals of different kinds, chiefly crustacea, as shrimps, crabs, and amphipodes. In the colouring there was great variation, even the form of the body was subject to considerable changes. Two principal types, however, could be distinguished, one thick and short, reddish form, comprising the individuals that had stayed on see-weed bottom, whose rich fauna of crustacea served it for food, and a greenish or greyish form, distinguished by a more slender structure of tbe body. These latter ones had chiefly stayed on sandy bottom, the animal life of which is poorer. In the stomachs of such individuals were also found different crustacea and young fishfrogs *(cottus scorpius).* By setting out a sink-line near sea-weed grounds at some distance from the shore, Sars caught a lot of small cods, of the length of about 1 foot (314 mm.). A few larger individuals also occurred, whose age was put at 2 years.

Mr. Sars, by careful examinations, formed the opinion that the main mass of the young cods that live during spring and autumn on tbe sea-weed ground is made up of last year's fry. That the sea-weed cod in Lofoten is the fry of the ocean cod seems to be quite certain from tbe investigations of Sars. There further occurs in Lofoten, especially at the beginning of the fishing, a cod-form called "opsigfisk" or "egfisk". It is thus described: "The form of the body is thicker and more clumsy than in the ocean cod proper; the head is not so pointed, the back of the neck is comparatively broader, the predominating colour has a distinct brownish-yellowish tinge, the dark spots were more numerous and reacbed farther down the sides than in the ocean cod, the teeth were also considerably smaller and fewer in number." It is further remarked that the "opsigfisk" consists of sexually ripe individuals. By very careful comparisons, Sars found that transition forms existed between the two; that none of tbe special distinguishing marks of the "opsigfisk" could be considered as constant, and that the existing difference must be considered as derived from accidental circumstances, as food and staying ground. Sars has stated the opsigfisk to be the stationary cod form of Lofoten, and this is no doubt correct. It would not agree with the tendency of nature to utilize space if all the fry developed in Lofoten should emigrate to the ocean banks and the edge. Nor is the thing so simple; the majority certainly emigrate, but a smaller part also find themselves provided for on the inner banks and the inner edge, where particularly the larger individuals are staying. Here they develop to sexual maturity, and therefore at the beginning of the fishing appear at the fishing stations as opsigfisk.

Thus the principal features of the post-embryonal life of tbe ocean cod are as follows: It is difficult for the new-hatched fry to undertake greater movements on account of their comparatively large yolk-sac, tbey keep to the surface of the water, and are subjected to the motions of the surface water. After the yolk-sac has been absorbed, and the power of moving about has increased, they move into deeper water, but they must still be classed to plancton organisms, and their food during this time is solely of planctonic kind. According to my plancton tables the food during the first time is not much varied; it seems chiefly to consist of larvæ of copepods, annelids, and echinoderms, together with young specimens of *calanus finmarchicus, oithona similis,* &c.

The young fish, having towards the end of the summer reacbed a lenght of 26—30 mm., begin moving towards land in order to take up a more stationary way of living, and the transition from the pelagic life to a littoral one is mediated, according to Sars's investigations, by a symbiosis with the jelly-fish. That however a great deal of the fry skip over this intermediate stage and move directly towards the shore, seems likely, as jelly-fish scarcely occur in such numbers, that these millions of tiny cod can find hosts. The strange circumstance that the young cod at a certain period seek company with the jelly-fisb, must problably be explained by the instinctive craving for a hiding-place. In the transition period between pelagic and littoral life, they are therefore also found among drifting objects crowded together by the current, and partly occur in great masses swarming round the outer skerries and rocks, where they are unsparingly pursued by green cod, sea-gulls, &c. Gradually they tben move up into the rich crustacean world of the sea-weed belt, which they once more leave in order to seek the submerged rocks and sea-weed grounds of the fjord. While one part is left to stay on the

latter, thus taking the character of stationary fjord fish, another and larger part move further and further out on the ocean banks and the large edge towards the deep of the arctic sea, whence they then return ripe for propagation. At this period they deliver their tribute to the Lofoten fisheries, but the greater part of those that escape the fishing tackle, return, after having spawned, to their oceanic life. After the Lofoten fisheries there is usually the "skraapfiske", which is most successful in Vesteraalen, for instance at Gaukværö. This seems to indicate that the fish-masses on returning from Lofoten move northward. Even late in the summer some stray specimens of the Lofoten cod may be caught, and these have as a rule an emaciated appearance.

The principal features of the life of the cod, as stated above, may be modified in different ways. Mr. Sars gives instances of this in his report for 1870. In the month of June the sand eel *(ammodytes tobianus)* draw near the shores in order to spawn. Consequently masses of cod, small and large, pursue it. By opening the stomachs of cods taken, Sars found that the contents almost exclusively consisted of ammodytes, especially at the beginning of the migration of the latter fish. Afterwards, when young herrings appeared in numbers in the same places, the sand eel was refused, and cod, as well as green cod, were found crammed with young herrings.

On the basis of Mr. Sars's investigations and materials, professor Collett*) has given the following measures for the young of the ocean cod:

½	month	old,	total	length	7—8	mm.
1	—	-	„	„	12	„
2	—	-	„	„	15—20	„
3	—	-	„	„	30—40	„
4	—	-	„	„	54—60	„
5	—	-	„	„	75	„
6—7	—	-	„	„	120—130	„
8—9	—	-	„	„	about 195	„
9—10	—	-	„	„	„ 240	„
12	—	-	„	„	400—500	„

In the summer following on their hatching the cod, at least a great part of them, are supposed to move out upon the outer banks, in order to return, at three years of age, ripe for propagation. For ocean cod ripe for propagation, Collett (l. c.), puts the length at 650—700 mm., while of the fjord cod the smallest individuals ripe for propagation have the length of 350—400 mm. A few times I have undertaken measurements of young cod caught close to the Biological Station. On August 26th, 1895, the aquarium was supplied with a number of young cod whose length was found to average about 80 mm. On September 15th they all died from want of air as the conduit had been choked. In the mean time they had been well fed on *mytilus edulis*, and the following sizes were found: 104, 88, 87, 93, 85, 85, 98, 97 mm., average about 90 mm. In 20 days the growth was consequently about 10 mm. For another and larger lot, the feeding of which had been less regular on account of the greater number, the increase during the same time averaged 6 mm. This observation from the aquarium, however, cannot of course be directly applied to the relations in free nature. This fry that on August 26th had an average length of 80 mm. were of course belonging to the progeny of the year, after the normal spawning time. At the beginning of June of the following year a few shoals of young cod were seen near the station building, some of which were caught and had a length of 140—215 mm. These could not belong to the hatch of the year, but at the same time they were also rather too small to be in their second year. Even supposing that the spawning had taken place in the month of February, they were still too large to be of the fry of the year; if however we suppose the spawning to have taken place in May, this fry would have been one year old, and even under that supposition they differed rather much from the normal size that professor Sars has found for the one year old progeny of the ocean cod in Lofoten. In another part of the coast, in the harbour of Larvik, I undertook, Nov. 25th, 1896, some measurements of small cods. The length was here 190—200 mm., which very well agrees with the measnres given by Sars for the corresponding stages of development from Lofoten. The stomach was crammed with amphipods (e. g. *gammarus)* and decapods (e. g. *crangon vulgaris).*

The majority of the fry of fishes is obliged to live on plancton organisms, and while some continue plancton eaters all their life (e. g. herring, sprat, &c.), there are others that, after eating nothing but plancton during the first part of their life, later on change to a mixed food of plancton and necton. The green cod *(gadus virens)* is no doubt such a one, probably the mackerel too. Further, there are some that rather soon leave off feeding on plancton, the place of this food being taken by the rich crnstacean fauna of the littoral region. This is the case of the cod, and Sars has shown that for the Lofoten cod the change is made when the young have reached the length of 50—60 mm. That the young green-cod continue feeding almost exclnsively on plancton until they are at least one year old, seems to me evident from the observations I have made; though more about this later on. This circumstance also explains the difference existing between the fry of cod and that of green-cod in the choice of their staying place. At the periods during which sufficient food is found in the surface layers, the green-cod fry stay at shallow places (in small bays and in harbours), while they move into deeper water in the typical winter months, when the plancton is extremely scarce in the upper layers.

As for the grown-np fish (cod, green-cod, &c.), I have in the following tried to give a somewhat detailed description of their feeding conditions.

The food of the cod.

The celebrated knower of fishes, Mr. Kröyer, writes about the cod that it may, on account of its voracity, be regarded as the enemy of nearly all sea animals that it can master. It is however of considerable interest to see what turns up in its stomach in different places and at different times. I have therefore examined a great number of cod stomachs. The conditions under which the cod feeds in our waters have of course been investigated before, especially by the professors Collett and Sars. In "Meddelelser om Norges fiske i aarene 1875—78", p. 65, Collett writes: "The animal forms that contribute the chief food for the larger individuals

*) Professor Collett, Norges Fiske, p. 104—107.

of this species are nearly always caught on the bottom of the sea, or close to it, and largely consist of decapods and echinoderms, as well as different bottom fishes." In July 1878 COLLETT found numbers of cod stomachs filled with *hyas araneus* and *ophiopolis aculeata;* he further also frequently found some small holothurides, as well as annelida and gephyrea. Of fishes he found especially *icelus, centridermichtys,* and the young of *anarrhichas, sebastes, lumpenus, chirolophus, centronotus, cyclopterus,* and other bottom fishes. Previous investigations have also shown that the fishes that particularly in great masses supply food for the cod are *mallotus villosus, clupea harengus,* and *ammodytes tobianus.* The latter three species are on a large scale used as bait for the cod. Dr. P. OLSSON *(Acta universitatis Lundensis, VIII,* 1871), in his "Iagttagelser öfver skandinaviska fiskars föda", mentions the following fishes as having been taken from the stomachs of cods: *Gadus merlangus, g. æglefinus, g. minutus, clupea, cottus scorpius, pleuronectes limanda.* G. O. SARS, by examining the stomach contents of cod caught at Spitsbergen, found individuals of the arctic species of *lycodes.* Finally, as a rare occurrence, *argyropelecus olfersii* and *argentina sphyræna* have been found in the stomach of *gadus callarias.* The only specimen of *macrurus coelorhyncus* (Risso) that is known to have been observed at the coasts of Norway, was found by Mr. SARS in the stomach of cod (at Herlövær, north of Bergen, Feb. 1842).

The following fishes I have taken from cod stomachs: *liparis sp., sebastes marinus, chirolophus galerita, anarrhicas lupus, gobius sp., gadus callarias, hippoglossoides platessoides, g. æglefinus, clupea harengus.*

In order to give a picture of the variety of organisms that contribute to the feeding of the cod, I here give descriptions of the stomach contents for different places on the coast of Norway.

Feb. 20th, 1896. Ocean cod (skrei) caught on the banks off Kristiansund N. A great number of the stomachs were empty. Contents: Herrings, decapod crustacea, *cypridina norvegica,* G. O. Sars.

March 6th, 1896. Ocean cod (skrei) caught at Svolvær, Lofoten, at 40—50 fathoms. Most of the stomachs empty or containing only remainders of the bait. The roe rather loose.

March 18th, 1896. I examined a large specimen caught at Henningsvær, Lofoten. Measures:

From end of tail to pectoral fin 855 mm.
„ pectoral fin to snout..... 315 „
Total length 1170 mm.

Stomach containing: Herrings, *sipho glaber.*

April 20th, 1896. Balstad, Lofoten. Out of a considerable number, only one had filled roe-bags. Stomach contents: *Hippoglossoides platessoides,* ophiurides, &c.

April 30th, 1896. Balstad. *Ophiocten sp., sipho sp.*

Feb. 10th, 1897. Sunderö in Vesteraalen. A number of one hundred fishes. The largest ones had a length of 120 cm. In rather many of the stomachs were found solid objects, only a few were quite empty, there being at any rate found a whitish semi-liquid pulp. In the guts the dissolution was so far advanced, that no determination of the contents was possible, but that the food had been of various kinds appeared from the colour of the contents. The latter would be greenish, reddish, yellow, greyish-white, &c. A granulary, reddish pulp in the guts testified to the animal having eaten chiefly echinoderms. In the gut were often seen cestodes, and in the stomach nematodes. Of ectoparasites, *caligus* was common, a few times *lernæa branchialis* being observed. The fish examined had been taken in a net. Besides cods, also lings and green cods had been taken. Several specimens of cod and ling had been consumed by myxine, which had eaten all the flesh, and also roe, liver, heart, &c. Only the bones and skin were left, the swim-bladder and the stomach being also as a rule left intact. What remained of the guts was empty, the contents of the guts had probably also disappeared. What might have been left by myxine had been done away with by amphipods. Thus, under the skin of the sucked-out fishes were found a great number of specimens of *hoplonyx cicada,* Fabr. On one occasion we got up a cod that had only been half eaten by myxine. On cutting it open, as much as 7 specimens were found of this mischievous animal, which the Lofoten fishermen call "worm".

Contents of the cod stomachs:

Ommatostrephes todarus, ciona intestinalis, munida rugosa, hyas coarctatus.

Feb. 12th, 1897. Sunderö. Number, 40. The majority empty.

Contents: Shells (pecten), remainders of decapod crustacea and ophiurides, *sebastes marinus.*

Feb. 17th, 1897. From the fishing sea off Svolvær. Stomachs generally empty, in some specimens *boreophausia inermis* was seen.

March 3th, 1897. From Höla in Lofoten. Fishes taken on setlines at a depth of about 50 fathoms. Many stomachs empty, or only containing remainders of the bait. The gut generally well filled with greenish, yellow, or grey contents according to the description of the food.

Number examined: 100.

Contents: *Pandalus brevirostris, pandalus sp., crangon almanni, hippolyte polaris, boreophausia inermis, parathemisto oblivia,* opercula of gastropodes. Of *boreophausia inermis* a considerable number were found.

March 16th, 1897. Svolvær. Number: 100 fishes. Among those examined was found a specimen whose liver was green throughout. The greater part of the cods still retained their roe. Some stomachs empty. Stomach contents: *Candalus sp., crangon almanni, boreophausia inermis, tysanoessa neglecta, idothea baltica, parathemisto oblivia, paroediceros lynceus, hippomedon denticulatus, euchæta norvegica, ophiura sarsii, modiola modiolus,* opercula of buccinum, *ciona intestinalis,* the low jaw of a fish.

The occurrence of ascidians in cod stomachs I have not previously seen observed, and it is probably the first time that any copepod has been observed in the stomach of the cod. However, of *euchæta norvegica* only one specimen was taken, a female with adjoined spermatophores.

March 29th, 1897. Reine in Lofoten. Number: 100 fishes.

Contents: *Buccinum sp., buccinum undatum, sipho glaber, boreophausia inermis, cypridina norvegica, gadus æglefinus*. 28 cm. long.

The majority had now spawned, the roe-bags were bluish-red, and testes had not the prominent white colour as before.

March 31st, 1897. Reine. Number: 250.

Now that the cod had spawned, many of the stomachs were empty too; the contents however indicated that the appetite at any rate had not become less than before. Besides remainders of the bait, the intestines of cod were often found, in an isolated case was even found a large head of a cod. The thing is that the cutting up of the fish is often done while the fishermen are rowing home from the fishing places: the instetines are then thrown into the sea.

Stomach contents: *Idothea neglecta, i. baltica*, remainders of *amphipods*, remainders of *holothurides, ophiura sarsii, onuphis conchylega, mytilus, sipho glaber, buccinum undatum, opercula* of *buccinum*. Some of the cods examined had their stomachs almost crammed with tentacles of *holothurides*. Mr. Hj. Östergren at Upsala has been good enough to examine this material, and says that most of them belong to *phyllophorus sp.*, and a few to *cucumaria frondosa*.

April 12th & 13th, 1897. Balstad. Number: 400 fishes.

In the largest cod-stomachs were often found the intestines of cods, in some even the heads. With a brachyopod *(waldheimia)* followed also the stone to which it had stuck. That a great part of the small stones that are frequently found in cod stomachs have come there in a similar way, is most likely. That the cod should take "ballast" before it again seeks out into the deep sea, is not very credible. At Balstad I found for the first time a starfish in the stomach of a cod, viz. a young specimen of *cribrella sanguinolenta*, and also a young individual of *solaster endeca*.

Contents: *Strongylocentrotus dröbachiensis, solaster endeca, cribrella sanguinolenta, ophiura sarsii, opercula* of *buccinum, pecten tigrinus, lunatia montagu, waldheimia, onuphis conchylega, leodice norvegica, nymphon strömii, halirages fulvocinctus, ampelisca sp., pandalus annulicornis, ciona intestinalis*.

Here at Balstad too, tentacles of *holothuridæ* were very common. Mr. Östergren mentions one nearly complete specimen of *stichopus tremulus*, as well as tentacle coronas and loose tentacles of *phyllophorus sp.* The calcareous substances of the skin and the tentacles were dissolved, as were also in nearly all of them the calcareous ring. Among other curiosities found in cod stomachs at Balstad was also a bit of orange peel.

April 28th. 1897. Röst in Lofoten.

Contents in cod stomachs: Remainders of *decapod crustacea, ephausidæ* and *amphipoda*.

From the cod fisheries off Kristiansund N. (March, 1897) I have examined about 900 cod stomachs. The fish were caught 4 miles SW of the Grip lighthouse. A great deal of the stomachs were empty, or contained only the remainders of the bait; I found, however, also remainders of fishes and cuttlefish, further crustacea (decapods, isopods) and snails.

Specification of the contents:

Remainders of *ommatostrephes, sipho gracilis, s. fusiformis, opercula* of *buccinum* and *sipho, munida rugosa, crangon almanni, æga strömii, rocinella danmoniensis, cirolana borealis, cypridina norvegica*.

From the fishing off Kalvaag, Bremanger, in March 1897, I examined about 200 cod stomachs. Simultaneously with the fishing of cod, "spring herrings" were also being caught, and the majority of the cod stomachs were filled with herrings or herring spawn in different stages of development. About half the number of the stomachs examined were filled with herring spawn, and the other half with spring herrings. With the spawn followed algæ, shells, &c. A great part of the spawn was so far developed, that the eye-spots were distinctly visible. Further, one specimen was found of *anarrhicas*, 19.5 cm. long, as well as remnants of other fishes, besides specimens of *ascidia mentula*, o. f. m., several gastropods and opercula of the same, *galathea sp., cribella sanguinolenta*, &c. In one stomach were found several balls of algæ. The general occurrence of spring herrings and herring spawn in the cod stomachs deserves special attention. The largest specimens of herrings observed measured as much as 28 cm. Among molluscs taken from cod stomachs from the Bremanger fishing may be mentioned: *Buccinum undatum, trichotropis borealis, nassa incrassata, chiton marmoreus, margarita grönlandica, lunatia montagui, cribella sanguinolenta, ophiura sarsii*.

Also in March 1898 cod fishing took place off Bremanger. Instead of the cod stomachs crammed with herrings and herring spawn as I had seen them the previous year, the March fishing of 1898 only supplied me with rather empty and shrunk stomachs for examination. In some, however, I found remnants of fishes, among these also herrings, but in no case spawn was found. Generally speaking, there seems this year to have prevailed scarcity of food. In the stomachs of cods taken near Bergen in March 1897 were, among other things, also found herrings, and spawn of *cottus*, while there were traces of *portunus depurator, galathea strigosa*, &c.

During the cod fisheries off Sotra (a little South of Bergen) in February 1898, I have further made some observations about the food of the cod.

On Feb. 23th, 1898, about 900 stomachs were examined, most of which were empty and shrunk, as in Lofoten, or only containing rests of the herring bait. In a few specimens spring herrings were seen; of other fishes were found one *sebastes*, one *gobius*, and indefinable rests of others. Among other things were found strips of *laminaria*, the jaws of *ommatostrephes*, many apercula of *buccinum undatum*, further specimens of *nassa incrassata, lunatia montagui, margarita grönlandica*, &c. In a few cases were seen *ascidia* and *holothuridæ*, and of larger crustacea may be noted *cancer pagurus, carcinus moenas* and *lithodes maja*. Further may be mentioned several smaller *amphipoda*, one *isopod (æga psora*,

Linn.), *schizopoda,* and a few specimens of an *ostracod.* Finally I should mention two specimens of an *actinia (metridium dianthus), tubularia tubes,* and a few *annelidæ.*

In this connection may be mentioned that the stomach of an ocean cod, caught in the same district on March 4th, 1897, contained a specimen of *gadus callarias,* measuring 30 cm.

Hitherto I have only accounted for my examinations of the stomach contents of ocean cod or skrei from different parts of the coast; also on the food of the fjord cod I bave made some observations.

February 1897. Stomach contents of fjord cods bought at tbe Bergen fish market:

Chirolophus galerita, rests of *ommatostrephes, lima hians, pandalus sp., munida sp., portunus depurator, ophiopholis aculeata.*

In the stomachs of fjord cods caught in tbe Herlö-fjord Apr. 12th, 1897, were found in the same manner different decapod crustacea, as *munida* and *lithodes maja.*

There are also instances that cods have swallowed lemmings. Thus in the Meisfjord, Alstadhaug, a cod was caught which, on being opened, proved to contain no less than 16 of these animals (Norsk Fiskeritidende 1891, p. 167). Professor Collett mentions that *alca torda* is sometimes found in the stomach of the cod, and there are also accounts to hand of young *somateria mollissima* having been taken from cod stomachs.

It thus appears from existing observations that the following groups have yielded larger or smaller contributions to the greediness of the cod:

Mammalia, aves, pisces, cephalopoda, lamellibranchiata, gastropoda, brachyopoda, crustacea, echinida, ophiurida, holothurida, actinida, hydroida.

The class of animals that chiefly suffers is crustacea, of which the following orders are represented: *Podophthalmata, isopoda, amphipoda, ostracoda, copepoda.*

Employing terms taken from Hæckel's division of the world of organisms, it may be said that the cod, in our waters, chiefly feeds on benthos; tbe occurrencc however of great masses of necton forms (herrings, sand-eel, capelan, cuttlefish, &c.) causes that the cod almost entirely abandon the bottom animals in order to indulge in the far more laborious cbasing of shoals of fish or cuttlefish. Thus it is the latter quality in the cod that causes for instance the Finmarken fisheries, and it is likely to be this same quality that has made the fishermen complain that the codfisbing in Lofoten takes a rather irregular coursc when during the fisbing season shoals of herrings appear in the Lofoten seas.

Further there are instances that a plancton organism *(limacina helicina)* has caused a crowding, together of cod, by which considerable catches could be made.

Of other plancton animals I have only found *borcophausia inermis* in numbers worth mentioning. That a form like *euchæta norvegica* may occur in cod stomacbs proves that, when full-grown, it does not refuse the small things. It is not very likely tbat this copepod should have entered together with other food, consequently the cod has snatched at it.

In this connection may be mentioned that I have been struck to find a certain ostracod *(cypridina norvegica)* occurring several times in cod stomachs. According to Sars*) the animal possesses a strong lighting power, and it may then be tbis very quality that makes it end its life thus often in the stomach of the cod.

With a claim to correctness it may finally be said that in the housebold of the cod benthos is of greatest importance, then follows necton, then plancton, the importance of which bowever is small compared to the two former principal groups.

Occasionally in my expeditions I have also examined the stomach contents of other fishes, especially *gadus æglefinus* and *g. virens.* In the annual reports of the Tromsö Museum, no. 16, 1893, Mr. Schneider has given a list of shell-decked molluscs taken from the stomach of the haddock at Vardö. The author gives no less tban 92 species, whereof 3 *brachiopoda,* 25 *conchifera,* 1 *solenoconchia,* and 63 *gastropoda,* among the latter such a rarity as *scalaria obtusicostata,* Wood. It is a high percentage of the arctic mollusc fauna that has been brought forward in this manner. Of course the haddock in the Vardö sea also feeds upon *echinodermata,* but investigations of this are not to hand. During my stay at Sunderö in Vesteraalen at the beginning of February 1897, I examined several haddock stomacbs, which went to show tbat, there at least, the *echinodermata* afforded the principal contingent to the food of tbe haddock. The specimens werc taken in nets together with cod and green cod, the most common sizes being 65—68 cm. The roe appeared ready for spawning; I saw however, as late as May 5th, baddocks with filled roe-bags at Röst. The majority of the haddock, like the cod, probably spawns in the month of March. Stomach and gut were as a rule crammed with rests of *echinodermata,* more rarely appeared molluscs, and still more rarely worms.

Animals from thc stomach and gut of the haddock:

Feb. 7th, 1897. Sunderö.
Gibbula tumida.

Feb. 8th, 1897. Sunderö.
Terebratulina capus serpentis, pecten sp., strongylocentrotus dröbachiensis, ophiopholis aculeata.

Feb. 12tb, 1897. Sunderö.
Strongylocentrotus dröbachiensis, ophiopholis aculeata.

April 28th, 1897. Röst.
Strongylocentrotus, ophiopholis, phyllophorus sp., lcodice norvegica.

At Sunderö I also examined some green-cod stomachs, at the beginning of February 1897. I found none that had spawned, but the roe was quite ripe. The length of the green cod was about 80 cm. In the stomachs werc found rests of *ommatostrephes, amphipoda,* and *schizopoda.* A few had their stomachs crammed with *nyctiphanes norvegicus.* In green cod, caught April 28th, 1897, in the By-fjord of Bergen, were also found large quantities of *nyctiphanes,* as well as small herrings and sprat. G. O. Sars has

*) Oversigt over Norges marine Ostracoder, Christiania Vid. Selsk. Forh. 1865, p. 106.

taken many individuals of the latter *schizopod* in stomachs of *sebastes* caught in the Kristiania-fjord.

Of amphipods in stomachs of green-cod (Feb. 8th, 1897, Sunderö) may be mentioned *parathemisto oblivia, euthemisto compressa,* and *euthemisto bispinosa.* The two latter ones have only been observed in a single locality, viz. at Sörö in Western Finmark (G. O. Sars).

During the fishing at Röst at the end of April 1897 there occurred, together with the ocean cod, several other fishes, as torsk *(brosmius brosme),* ling *(molva vulgaris),* haddock *(gadus æglefinus),* halibut *(hippoglossus vulgaris),* sea-cat *(anarrhicas lupus),* Norway haddock *(sebastes marinus).* It was difficult to examine the stomach contents of torsk and ling as the stomach as a rule stood far out of the mouth when the fishes came into the boat. Only exceptionally the stomach had its natural position. In stomachs of lings I saw bones of haddock (both at Röst and at Sunderö). In stomachs of torsk were found *decapod crustacea,* chiefly *lithodes maja,* the spines of which were visible on the outside of the stomach, without however having pierced the stomach bag. Besides crustacea I have seen annelida *(leodice)* in the stomach of torsk. The gut of *anarrhichas* was as a rule filled with a gruel derived from *echinodermata.*

The largest ling I saw during my stay at Röst measured 1.5 metre. The females had at the end of April unripe roe.

On the feeding circumstances of the haddock in the neighbourhood of Bergen, some observations have been made.

Mr. Grieg, curator at the Bergen Museum, has defined the following forms from the stomach and gut of the haddock:

July 9th, 1897. Hjelte-fjord.

Ophiopholis aculeata, ophiura squamosa, amphiura squamata, echinocyamus pusillus, lima hians, l. loscombi, limatula elliptica, l. subauriculata, cardium fasciatum. The most common of these forms were *lima hians* and *loscombi, cardium fasciatum,* and *ophiura squamosa.*

Dec. 16th, 1897. Herlö-fjord.

Gasterosteus aculeatus, munida, æga, pecten septemradiatus, p. similis, p. vitreus, arca pectunculoides, portlandia tenuis, philine scabra, cardiun fasciatum. To the rather common ones belonged *pecten vitreus* and *arca pectunculoides.*

Dec. 23th, 1897. Herlö-fjord.

Stichopus tremulus, ophiopholis aculeata, ophiura sarsii, strong. dröbachiensis, pecten vitreus.

Echinodermata and molluscs afford, in our waters as elsewhere, the chief quantity of the food of the haddock, but besides, this fish eats bottom crustacea (as *munida, æga),* annelida, and even fishes. The haddock may consequently be characterised as a typical benthos-eater.

At the end of the Lofoten fisheries young green-cods *(gadus virens jun.)* are often used for bait for the cod. During my stay at Balstad late in April 1896, seines were regularly used to catch young green-cod, which in large shoals swarmed in the harbour. The following measures, from the snout to the tail-fin, give a fair idea of the sizes that occurred: Balstad, April 20th, 1896, — 24.5 cm., 24.5, 19, 26.8, 25, 13, 13.5, 14, 13 cm. Among the young green-cod occurred a few small cods, one for instance 31 cm. long, which however was more like skrei than ordinary fjord-cod. Among the smaller specimens of the young green-cod the majority were bluish-black on the back and bluish on the sides, a few however had a reddish tinge on the sides and fins. On their being opened, the stomach was seen to be much expanded, and in the smallest specimens some peculiar granulary contents were perceived through the expanded skin of the stomach. These contents soon proved to consist chiefly of fish spawn, among which also the spawn of the ocean cod in great numbers. When it is considered that every harbour in Lofoten in the spring swarms with very young green-cod which incessantly snatch at fish-spawn, one gets an idea of the enormous destruction that the germs of the cod are exposed to from the progeny of its kindred. In the stomachs were found, besides fish-spawn, a great number of *cypris* and *nauplius* stages of *cirripedia,* also *microsetella atlantica* was observed, as well as another copepod, which professor Sars has defined as *thalestris gibba,* (Kröyer).

On April 30th, 1897, I caught, off the quay at Glea (Röst), some young green-cods measuring about 13 cm. Here too fish-spawn was found in the stomachs, though not in such a large number as at Balstad the previous year. At the time there was however, at any rate inside the harbour, not very much spawn. The greater part of the stomach contents consisted of *cirriped cypris*; further there appeared *larvæ* of *euphausida* and *copepoda, zoea* of *brachyur decapod, calanus finmarchicus, pseudocalanus elongatus, harpacticus chelifer,* &c. In the harbour of the hamlet there were at this time large masses of young green-cod, a great deal of boats were moored there, and it was interesting to observe how the small fishes with predilection stuck to the shadowy side of the boats. In none of the stomachs of the young green-cods that I examined I found bottom animals. It is likely that green-cod feed almost exclusively on pelagic organisms, the younger stages being limited to plancton, and the grown-up ones to the larger plancton forms *(boreophausia, nyctiphanes, parathemisto,* &c.) as well as necton (cuttle-fish, herrings, sprat, sand eel, capelan, &c.). In Lofoten Mr. G. O. Sars has observed that green-cod occur in large numbers in the month of July, chasing the fry of the cod as well as their own. On one occasion the professor even succeeded in making a green-cod disgorge a couple of live young cods. It might appear that the green-cod had several advantages in competing with the cod, but nevertheless the two species may keep alongside each other in large masses in the same area. The cod lack the power of the green-cod for cooperation, and the green-cod are likely to make a greater destruction of the eggs and fry of the cod than *vice versa,* but as the green-cod does not spare their own young, which of course in their turn make no difference between cod-spawn and green-cod spawn, this circumstance is likely to keep up the balance between the two nearly related species.

On the weight of the ocean cod the supervising chief Mr. Knap has caused a series of observations to be made. Thus the average weight for the whole of Lofoten was found to be as follows:

	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891
	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
Net-fish, split	2.07	2.74	2.58	2.83	2.70	2.53	3.08	3.38	3.19	2.85
Sinkline-fish, „	2.38	2.44	2.02	2.26	2.38	2.30	2.94	3.11	2.70	2.56
Liver of netfish	0.37	0.17	0.23	0.24	0.37	0.23	0.37	0.38	0.38	0.45
— „ linefish.....	0.22	0.13	0.15	0.20	0.22	0.20	0.40	0.37	0.38	0.28
Roe of netfish.....	0.56	0.39	0.36	0.55	0.56	0.44	0.45	0.56	0.71	0.68
— „ linefish	0.34	0.39	0.29	0.36	0.34	0.37	0.46	0.38	0.54	0.53

During the fishing season of 1889 a great deal of measurements and weighings were undertaken. The length varied between 74 and 100 cm., and the weight of the fish in round condition averaged from 4.5 to 8.8 kg. for different fishing stations. Sometimes specimens are caught of unusual size. On April 13th, 1888, two fishes were caught off Skraaven, weighing 31 and 37 kg. respectively, and off Svolvær, on March 17th in the same year, a cod was caught measuring 1.45 m. in length, and 1.02 m. roung the belly, the weight being 43 kg. (Helland, Lofoten og Vesteraalen, p. 161).

On March 23th, 1897, a cod was taken in a net off Brettesnæs whose length was 1.45 m., total weight 36.5 kg., weight of the roe 6.7 kg., of the liver 3.3 kg. It is not only in Lofoten that cod of such dimensions occur. According to Norsk Fiskeritidende, 1887, p. 301, a cod was caught June 7th, 1887, at Losvik in the Tana fjord whose length was 1.53 m. and weight in round condition 37.5 kg. Of this weight, that of the body was 25 kg., head 7.1 kg., liver 2.5 kg., and intestines 2.9 kg.

In conclusion I give a list of the most important animals that are used as bait for the cod in Lofoten:

Clupea harengus.
Mallotus villosus.
Ammodytes tobianus.
Gadus virens (juniores).
Ommatostrephes todarus.
Cyprina islandica.
Mytilus edulis.
Modiola modiolus.
Arenicola piscatorium.

b. Notes on certain plancton forms.

Galeolaria (diphyes) truncata, M. Sars.

A few specimens of this siphonophor I took Feb. 5th, 1898, in the Hjeltefjord near Bergen, at from 0 to 190 m. the largest specimen had a length of 15 mm.

Mr. M. Sars*) has taken the species at Florö in the months of September, October, and November.

It has further, been observed by the German North sea Expedition of 1872, July 25th, in the surface, near Lindesnes.

Pleurobrachia pileus, Fabr.

Till now I have only met with a single ctenophor, viz. *p. pileus.* It was taken close outside the Bergen Biological Station in the autumn 1896 by the keeper, Mr. Glimme. The species thus appeared in samples taken from the Puddefjord from November 17th to 24th, 1896. Afterwards it has not been seen at this place. In the sample of Nov. 17th a peculiar copepod also occurred, a kind of *monstrilla,* of which I have published a short characteristic in the Annual Report of the Bergen Museum for 1897.

Cyphonautes.

Outside the Biological Station *cyphonautes* was observed in the plancton in all the months of 1896 and 1897, excepting January—April inclusively. For occurrence elsewhere, see the tables. During the summer of 1896 colonies of *membranipora membranacea,* Linn., were often seen on the glass panes of the aquariums of the station. These were of course founded by *cyphonautes* that had entered with the water from the conduit.

*) Fauna Littoralis Norvegiæ, h. I., p. 41.

Bipinnaria.

In Feb. 1896 I took *bipinnaria* at several places along the west coast. The small five-armed sea-stars could distinctly be seen on all, and the arrangement of the processes on the larvæ makes it likely that all must be classed among *bipinnaria asterigera*, Sars. In a surface sample taken in 61° 9.5′ N. and 3° 50.5′ E., May 12th, 1896, a little sea-star was found the appearance of which corresponds well with the small ones on the *bipinnaria* mentioned. It seems to have been made evident that *b. asterigera* is the larva of *luidia sarsii*, whose spawning time must consequently be very irregular as Mr. M. Sars has observed the said larvæ in May, Messrs. Koren and Danielsen in the months September—October, and I in February.

Spadella (sagitta) hamata, Möbius.

This chætognath I have taken many times, both in the fjords near Bergen and in Lofoten, but never in shallow water. Mr. Möbius*) mentions it from the Korsfjord in depths of from 135 to 337 fathoms, while Aurivillius, during the Swedish Scagerrack Expedition of 1893—94, notes it from 0—100 m. in water whose saltness was 22.31—35.05 ‰, and temperature 2°.85—17°.3 C. Mr. Aurivillius**) gives the length at 18 mm. for specimens from the Swedish Scagerrack coast. The largest ones I have till now measured were 24 mm. (Feb. 23th, 1897; between Barö and Lödingen, 0—190 m.). Mr. Strodtmann states that *s. hamata* may reach the length of 3—4 cm., but such large individuals are probably only found in high arctic regions. I have the idea that *s. hamata* at our coast is thriving best in water of 6°—7° C., and with a saltness of 34—35 ‰. In some places, as in the Östnesfjord and at Sunderö in Vesteraalen, I have observed *chætognata* also in the surface, but this has been another kind *(s. bipunctata)*.

Tomopteris septentrionalis, Stenstrup.

In "Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn", 1849—50, p. IV, Mr. Stenstrup states that the Copenhagen Museum had received from dr. Rink a great number of specimens of this kind, in part taken a few miles off the Norwegian coast, in part in the sea round the Orkneys and the Faroe islands. Mr. Stenstrup considered it different from the form observed in the South Sea by Eschholtz *(t. onisciformis)*. In "Fünfter Bericht der Kommission zur w. Unters. d. Deutsch. Meere", Mr. Möbius (p 117) has mentioned a form, *t. helgolandica*, Greef, which in all probability is synonymous with *t. septentrionalis*. Besides in other places, the German Expedition has also observed the form mentioned in the neighbourhood of Lindesnes. Mr. G. O. Sars has informed me that he has often met with *tomopteris* both in the Kristiania-fjord and along the whole West-coast as far as Lofoten. In the many plancton samples that I have taken during the last two years, this form has only occurred a single time, namely Feb. 25th, 1897, in the Ofoten-fjord in a sample from 0—250 m. Further, dr. Appellöf took a fine specimen in the Bergen By-fjord in the summer 1894. It had a total length of about 40 mm.

Calanus finmarchicus, Gunnerus.

Mr. Giesbrecht has noticed that this is probably the first marine pelagic copepod that has been described. That honour belongs to the Norwegian bishop Johan Ernst Gunnerus (1718—1773). The original name was *monoculus finmarchicus*, and the original description is found in "Det Kongelig Norske Videnskabsselskabs Skrifter". This copepod seems to occur in the plancton at our coast at any time of the year, at least the females, the males on the contrary being rarer. Mr. Giesbrecht in his "Monographie" gives the following measures for the female:

At Naples ..... 2.7—2.9 mm.
- Gibraltar ..... 3.0 „
- Spitsbergen, the largest ones 4—4.5 „

The grown-up males are stated to vary between 2.35—3.2 mm. I have undertaken a number of measurements of both sexes.

Feb. 23th, 1897; between Barö and Lödingen; 0—200 m.
♀ 3.7 mm.
♂ 3.6 „
♂ 3.6 „

Feb. 24th, 1897; off the mouth of the Tjeldsund; 0—200 m.
♀ 3.7 mm.
♂ 3.3 „
♂ 3.2 „

July 1st, 1897; 15 geogr. miles north of Jan Mayn; 0 m.
♀ 5.0 mm.

Feb. 14th, 1898; Herlöfjord near Bergen; 0—400 m.
♀ 3.0 mm.
♂ 3.4 „

From this will be seen that even in the deep of the fjords near Bergen the male may reach the length of 3.4 mm., while in the arctic sea the female can reach a length of 5 mm. The upper limit of variation is thus somewhat extended.

Calanus hyperboreus, Kröyer.

♀

Apart from the difference of size, the female of *c. hyperboreus* is easily distinguished from *c. finm.* ♀, the lateral corners of the 5th body-segment being pointed in the former, while they are rounded off in the latter. The arrangement of teeth on the basal joint in the fifth pair of feet (fig. 28) also gives a good mark of distinction. The interval of variation is stated by Giesbrecht to be 6.9—9.6 mm. Having taken several specimens of the said form both in Lofoten and in the Ofoten-fjord, I give here some measures.

*) Jahresbericht der Commission zur wissentschaftl. Untersuch. d. Deutsch. M. II, III Jahrg., p. 158.

**) Das Plankton des Baltischen Meeres, p. 37 (Bihang t. Kgl. S. Vet. Akad. Handl. Band. 21, Stockholm 1896).

Feb. 23th, 1897; between Barö and Lödingen; 0—200 m.
♀ 6.5 mm., 6.6 mm., 6.6 mm.
Feb. 24th, 1897; at the mouth of the Tjeldsund; 0—200 m.
♀ 6.0 mm., 6.5 mm., 7.0 mm.
April 10th, 1897; at Balstad in Lofoten; 0—200 m.
♀ 6.5 mm., 6.8 mm.
June 25th, 1897; 15 geogr. miles NE. of Jan Mayn; 0 m.
♀ 6.8 mm., 8.2 mm., 8.5 mm., 9.2 mm., 9.3 mm.

Finally I have observed *c. hyperboreus* from the deep of the fjords near Bergen, namely in plancton samples from the Herlöfjord (Feb. 28th, and March 15th, 1898; 0—450 m.). The specimens were females, length 6.5 mm. The largest female individuals from the Norwegian coast have thus been about 7 mm., while the largest from the Arctic Sea measured over 9 mm.

C. hyperboreus ♂ (new).

Notwithstanding that in recent years a considerable quantity of plancton material from the arctic waters has been examined, nobody has observed the male of *c. hyperboreus*. I was therefore surprised to find, in the sample from Feb. 23th, 1897 (between Barö and Lödingen; 0—200 m.), a couple of male *calanus*, which I at once thought were too large to be the males of *c. finmarchicus*. By the preliminary examination I was soon disappointed by finding that the lateral corners of the last body-segment were rounded, thinking that the male *c. hyperboreus* must have pointed corners like the female. However, it was of course no necessary supposition, and after having investigated the matter more closely, I venture to say with certainty that it really were males of *c. hyperboreus* that I had before me.

Just as the females of the two species resemble one another very much, so it is the same with the males. A careful examination of the fifth pair of feet, however, may decide to which species a specimen belongs. Both males of *c. hyperboreus* that have been found have a total length that exceeds the maximum limit for at any rate the males of *c. finmarchicus*, and in our waters no females of the latter occur that can equal in length the said males.

Feb. 23th- 1897; between Barö and Lödingen; 0—200 m.

C. hyperboreus ♂	front part of the body	4.3 mm.	}	5.5 mm.	
„ „	- hind „ - - „	1.2 „	}		
„ „	- front „ - - „	3.6 „	}	4.8 „	
„ „	- hind „ - - „	1.2 „	}		

In the segmentation of the body (fig. 18), or in the structure of the anterior *antennæ* I have not been able to find any obvious difference between the two closely connected male *calani*. The appendices of the *antennæ* had mostly fallen off, but the remainders suggested the same form and the same reciprocal arrangement as in *c. finmarchicus*. Even in the structure of the 2nd pair of maxillipeds I have found no essential difference. However, an examination of the first basal joint will leave no doubt as to the species; for in the male *c. finmarchicus* the row of teeth goes quite to the edge of the joint or to the boundary between first and second basal joints (fig. 17); in *hyperboreus*, on the contrary, the row of teeth does not reach quite down to edge of the joint (fig. 29, 31). Besides, in the former the row of teeth makes a greater curve than in the latter, in which it comes very near to a straight line (fig. 16, 30). The inner edge of first basal joint is quite straight in *hyperb.*, but concave in *finm.* The left foot in fifth pair of feet seems also to be somewhat different in the two species. In *finm.* y_2 is longer than y_3, while in *hyperb.* it is shorter. The joint y_3 further has a somewhat different appearance, the joint narrowing very much towards the end in the former, while in the latter it is nearly equally broad throughout its length.

In the female of the two calanides the structure is the same as in the male, as for the arrangement of the teeth on the inner basal joint of the fifth pair of feet (fig. 27, 28). The occurring difference has first been noticed by Mr. Giesbrecth. While equally-sized females as a rule can be easily distinguished without examning the fifth pair of feet, it is probably necessary, in order to distinguish the males, to cut out the fifth pair of feet. The size will of course be suggestive of the species. The largest specimens of *c. finmarchicus* ♂ that I have hitherto found, measured 3.6 mm., and this size is not likely to be exceeded. Another hint to facilitate distinction is likely to be obtained from the form of the front part of the body. In *c. hyperboreus* ♂ it is, as it were, cut straight off (fig. 17), while it has been more pointed in the males I have seen of the other form. Thus it has also been drawn by Mr. Brady in report of the copepoda collected by H. M. S. Challenger, pl. 1, fig. 1. It may be worth noticing that the two males of *c. hyperboreus* were observed at winter-time. In samples from the Arctic Sea (summer 1897) I have seen females of *hyperboreus* by the hundred, but not a single male.

Paracalanus parvus, Claus.

In my tables this species is insufficiently represented, as for some time I did not distinguish it from *pseudocalanus elongatus*. Professor Sars*) mentions it among the species that serve as food for the sprat.

Pseudocalanus elongatus, Boeck.

The species is mentioned by Mr. Boeck both from the Kristiania-fjord and from the West-coast of Norway. It is one of the few species that occur in the winter plancton in Lofoten, where for instance it was found in great quantity under the ice in the Troldfjord. The most northerly place where I have hitherto observed the species is the Tromsösund, but no doubt it goes a good deal farther to the North.

Undinopsis bradyi, G. O. Sars.

In "Undersøgelser over Dyrelivet i Arktiske Fjorde", Mr. Sparre Schneider has mentioned a copepod that is called *undinopsis bradyi*,

*) G. O. Sars, Brislingen og Brislingfisket.

G. O. Sars. This species is said to have been found in Kvænangen and at Tromsö. In the summer 1897 I showed to professor Sars a preparation of a copepod that I had been unable to identify. He then declared it to be the very *undinopsis bradyi*, and afterwards informed me in a letter that the said copepod had been described and drawn by Mr. Brady (A monograph of the copepoda of the British Islands, I, p. 46, pl. IV, fig. 1—11).

The species was, however, there wrongly identified with *pseudocalanus armatus*, Boeck, which according to Mr. Sars is another species. As Mr. Sars, in his gigantic revision of Norwegian crustacea, will soon come to the copepoda, I shall do nothing but here note the occurrence of *undinopsis bradyi* at the following places:

March 14th, 1896; Vestfjord (67° 32′.5 N.; 13° 24′.5 E.).
In plancton 0—200 m.

March 5th, 1897; Östnes-fjord in Lofoten.

March 7th, 1897; Trold-fjord in Lofoten, plancton 0—65 m.

Besides, I have this year taken several specimens of the species from the fjords near Bergen.

Euchæta norvegica, Boeck.

Mr. Boeck took the specimens of this species on which the original description was based, at a depth of 300 fathoms, off Skudesnes. It has afterwards been mentioned from our waters by Möbius and Sars, which investigators have given extensive descriptions of the animal. In the North Ocean Expedition, the *e. norvegica* was noticed at 12 different stations, and always from a considerable depth.

In Lofoten I have observed the species in plancton samples from 0—100 m., viz.

March 23th, 1896; Reine, ♀ length 8.3 mm.

March 26th, 1896; Reine, ♀ length 8.32 mm.

I have further taken a female with attached *spermatophores* in the stomach of a cod caught near Svolvær, March 16th, 1897; length 6.6 mm. Mr. Sars gives 12 mm. as the measure of the largest specimens from the North Ocean Expedition, but this considerable length is not likely to be reached by the forms existing in our fjords.

Centropages typicus, Krøyer.

The North Ocean Expedition observed the species, besides in other places, on June 28th, 1876, at st. 26 (63°10′ N., 5°16′ E.). It probably goes somewhat farther northwards, but Mr. Boeck is scarcely right in saying that it occurs in great numbers along the whole of our coast. It was found, together with some other copepods, in a surface sample taken by capt. Thovsen in the North Sea, March 8th, 1898 (57° 21′ N., 2° 27′ E.), The surface temperature at the place was 7° C., saltness 35.03 ‰.

Centropages hamatus, Liljeborg,

has not yet, to my knowledge, been observed as far north as Lofoten. The North Ocean Expedition took the species in several places. Outside the Biological Station, *c. hamatus* has chiefly appeared in the late summer and autumn, simultaneously with *c. typicus*. Both these species were however also found in the line Stavanger—Newcastle on March 8th, 1898, in the surface of the sea.

Temora longicornis, O. F. Müller.

Mr. Boeck says that the species is very common in the Kristiania-fjord, but not quite as common on the West-coast. During the North Ocean Expedition it was observed, besides in other places, also at st. 124 (66°41′ N., 6°59′ E.) on June 17th, 1877. I do not think it has as yet been taken north of that latitude. The species in summer and autumn occurs in a large number of individuals in the fjord of Bergen. In the prolongation of the By-fjord on which the Biological Station is situated, *temora* occurred in the samples of every month in 1896—97, with the exception of March, and for the months June—October incl. it was very common indeed. In Lofoten it was, at any rate in the winters of 1886 and 1887, extremely rare.

Metridia hibernica, Brady & Rob.

Mr. Aksel Boeck described, in Transactions of Kristiania Videnskabsselskab for 1864, two species of the *genus* of *metridia*, a larger one that he called *m. armata*, and a smaller one, *m. lucens*. Mr. Giesbrecht has shown that *m. armata* = *m. longa*, Lubb., and as for *m. lucens*, the said author is of opinion that it can scarcely be classed to *metridia*, because, according to Boeck, it lacks hooks on the first joint at the inner branch of the second pair of feet. It is however likely that *m. lucens* and *m. hibernica* are identical; at any rate I have taken *m. hibernica* at several places, from Bergen to Lofoten. The north limit is pro tem. about the 69th degree of lat., most probably it goes considerably further to the north. According to the rules of priority the name of *hibernica* should, I suppose, yield to that of *luccus*, but as the species was originally described so insufficiently, that it cannot be identified with certainty, it may be right to keep the term of *hibernica*. While *m. longa* is known from Greenland (Aurivillius), Spitsbergen (Giesbrecht), the Kara Sea (Hansen), and has been taken by myself at different places from Bergen to Tromsö, — *m. hibernica* has not as yet been found north of the arctic circle. The fullgrown females of *m. longa* have a length of 4 mm. or a little more, while for the *hibernica* I can give the following measures:

April 10th, 1897. Balstad in Lofoten.
0—200 m.
♀ 2.5 mm., ♂ 1.75 mm.

Nov. 24th, 1896. Puddefjord, near Bergen.
0—8 m.
♀ Front body 0.96 mm.
Hind „ 1.68 „
} 2.64 mm.

Nov. 10th, 1896. Puddefjord.
0—8 m.
♂ Front body 0.60 mm. } 1.85 mm.
Hind „ 1.25 „ }

M. hibernica is easily distinguished from the *longa* by the pointed corners at the last body-segment (fig. 26), and by its comparatively shorter furca, the breadth of the branches being about half the length (fig. 25).

Metridia longa, Lubbock.

The largest specimens of this species I took in the Ofotenfjord. The largest female measured 4.29 mm. The males had a length of about 3.5 mm. *M. longa* occurs at greater depths in the fjords near Bergen, but the females here have scarcely exceeded 4 mm. The largest one I have till now measured was 3.9 mm.

Heterochæta norvegica, Boeck.

In Kristiania Videnskabsselskabs Forhandlinger for 1872, Axel Boeck has given a short diagnosis of a copepod that he had taken at a rather great depth off the Norwegian coast, and which on examination was found to be of a species differing from the forms described by Claus *(spinifrons, papilligera).* The said new species received the name of *heterochæta norvegica.* Giesbrecht, in his well-known "Monographie", has noted this as "Unbestimmbare Species", at the same time stating that some of the characteristics given suggest some known species. Boeck's description of 5th left foot of ♂ does not however agree with any of the species previously described. The original description of *h. norvegica* is as follows:

"The upper feelers are not as long as the body. The basal joint of the outer jaw-foot is armed with a strong thorn. The final part is distinctly separated. The first joint of the upper feelers is longer than the four others together. The outer branch of the second to fourth pair of feet is about three times as long as the inner branch. The final joint is very large, oval, supplied with three teeth in notches on the outer edge and at the point, as well as near the latter with three rough saw-teeth. In the males the basal joint of the right fifth pair of feet is drawn out into a very large curbed hook. The second joint of the outer branch has on the inner edge a knot. The third joint is drawn out into a strong point. In the left fifth pair of feet the third joint of the outer branch is shorter than the second, and inwardly drawn out into a strong point, against which a curbed claw from the point of the joint can strike". This short description, which is not accompanied by drawings, is certainly meant by the author to be only a preliminary one. It is seen from Boeck's work ("Nye Slegter og Arter af Saltvands Copepoder") that it was his intention to deliver an extensive work on the copepods. Death however abruptly put a stop to the realization of this plan.

By examing a sample from the Ofoten-fjord, taken Feb. 25th, 1897, depth 0—250 m., I discovered two specimens (♀, ♂) of *heterochæta* which showed a rather great likeness to *h. papilligera.* A closer inspection has proved that the specimens from the Ofotenfjord differ, especially in the structure of fifth pair of feet, from *papilligera,* while in all essentials they correspond with the description of *h. norvegica.* The latter will therefore, in my opinion, have to be maintained as a seperate species.

Description of ♀.

Length. Front body 2.70 mm. } 3.78 mm.
Hind „ 1.08 „ }
Greatest breadth 1 mm.

The front body consists of 5 segments, the two hinder ones being joined into one. Of these th1 and th4—5 are about equally broad, likewise th2 and th3, which however both are narrower than the two former ones. (The terms of Giesbrecht's denotation are here adopted). The head segment carries two extremely small hairs, pointed forwards, and the two rostral threads. The brow *papilla* is not pointed as in *h. spinifrons*, but bears an obvious likeness to the corresponding one in *h. papilligera.*

The hind body (fig. 11) consists of four segments, diminishing in length downwards; the genital segment is a little longer than the three following taken together. The joint connection between ab5 and furca is rather indistinct. The length of the furcal branches is not quite three times as great as the breadth, the left branch being a little longer than the right one. Each furcal branch carries 5 large brushes and, besides, an extremely small one on the inner side. One of the brushes on the left branch is much longer than the others. It was torn off both in the male and the female, but it is likely to be longer than the body in both of them. The piece that was left measured a little over 2 mm., and at the fracture the thickness had not perceivably decreased. The genital segment is on the ventral side very much swollen, dorsally it has a peculiar inward curbing. Besides, the genital segment and the two following ones carry on the dorsal side a series of thorns (fig. 11). In the former this thorny row sits a little above the lower edge, in the two others in the edge itself. The first pair af antennæ consist of 25 different pieces, of which the foremost one, which is pointed forward, is longer than the four following ones taken together. The length of the antennæ is 4.2 mm., they are consequently longer than the body, but as the proximal part is stiffly projecting, the antennæ when folded along the body will scarcely reach the end of the furca.

The posterior antennæ which are fixed to a comparatively long handle, have two branches, of which the inner branch is somewhat longer than the outer branch. The inner branch is made up of two joints of which i1 is about three times as long as i2 (fig. 10). The inner branch is made up of 8 joints, the outermost of which is longer than the 4 following taken together (fig. 24). The masticatory edge (fig. 21, 23), of the mandible has a characteristic armament, there being at one corner a curved tooth, at the other corner three teeth, with one, three, and two points respectively; at the base of the last-mentioned point also sits a little brush. The palp of the mandible consists of a short basal joint and a long one, to which are joined two branches, the outer branch being broader than the inner one (fig. 21). Both have feathery brushes at the top, besides a little feathery brush sitting at the second

basal joint. The maxilla are characterized by the inner branch (fig. 4) being very much reduced. The outer branch carries at the end 5 feathery brushes, and the redneed inner branch 3 extremely small ones. On one of the lobes of the basal part sit 5 very long feathery brushes, and on the other a group of at least 10 such. The first pair of maxillipeds are characterized by a comparatively long basal part, while the branches and lobes are very much reduced. At the distal end there are two groups of large brushes, three in each. In the upper group (fig. 7) the two are bent towards the end and set with fine points that give them a comb-like appearance. In the other group two brushes are equally long and equally thick, while the third is thinner and scarcely half the length of the two. The second pair of maxillipeds are considerably thinner in structure than the first pair, especially the second basal joint (b2) is much protracted, the length being 5—6 times the breadth. On the first basal joint b1 sits a very characteristic brush or thorn (fig. 14). It is curved and overlaps the distal end of b2. Besides there are at the end of b1 two short, thin brushes and one thicker brush or thorn. Near the inner edge of b2 is a row of small thorns. The lowest of the brushes (1) of the uppermost basal joint sits a little above the middle of the inner edge of the joint b2. Altogether there are on the inner edge of b2 5 brushes. Of these (1) and (2) are smaller than (3), wich is again smaller than (4). The branch consists of 5 joints, decreasing in length towards the end. Of these the 4 first joints carry 3 brushes.

In the first pair of feet the inner branch is almost as broad as the outer branch, and the length about $^2/_3$ of that of the outer branch. The first pair of feet is shorter than the three following. In the second pair of feet (fig. 8) the inner branch is not so long as the two lower joints of the outer branch, which is also the case for all the swimming feet 2—4; i3 is about twice as long as i1, and y3 longer than y1 + y2. In 3rd pair of feet y3 is comparatively longer and broader than in any of the others (fig.. 12). (There is no perceivable difference in the structure af 3rd pair of feet in the two sexes). 4th pair of feet is much like the 3rd, though the point of y3 short a somewhat different appearance (fig. 19). 5th pair of feet (fig. 3), like the others, consists of two branches, with 3 joints in each branch. The outer branch is about twice as long as the inner one; y1 lacks brushes, on y2 sits a thick curbed thorn, with the curbing turned inward (proximally). This thorn is a little longer than the inner branch. On the inner side of y3 are four rather long feather-brushes; the first brush is about half as long as the joint y3. Besides, i3 has 6 feather-brushes, and i2 has a thin, short brush, about half as long as the joint. A similar one sits on i1.

Apart from the comparative size, the female of *h. norvegica* shows great likeness to *h. papilligera* ♀. The best distinguishing mark I have found, is that the brushes on i1 and i2 on the 5th foot are considerably thinner and shorter than the brushes on i3. By the thin and short brushes on the two lower joints of the inner branch, *h. norvegica* shows a likeness to *h. clausii*, Giesbrecht. From the latter, however, *h. norvegica* is distinguished by lacking the thorn-like brush on y1. Besides it may be noted that in *h. clausii* the curbed thorn on y2 is shorter than the inner branch, while the final brush on y3 is more than half the length of the joint.

H. norvegica ♂.

Length	Front body	2.52	mm.
	Hind „	1.08	„
	Total	3.6	„

1st pair of antenna 4.0 mm., consequently longer than the body. Greatest breadth 0.9 mm. The long furcal brush was torn off, but the piece that was left measured a little over 2 mm., so it is likely that it is longer than the body.

The anterior left antenna is transformed into a clutching antenna, and is distinguished from the corresponding one in the female by several joints towards the distal end being joined into one (fig. 6).

The segmentation of cephalo-thorax is like that in the female, the hind body on the contrary consisting of 5 joints, of which the 4 uppermost have a row of small thorns at the hinder edge of the dorsal side (fig. 5). In the structure of the jointed organs of the body there is great likeness between the two sexes, only in respect of 5th pair of feet the likeness is lacking. The second basal joint in the right 5th foot has a characteristic projecting formation that is bent inwards towards the joint (fig. 20, 32); y2 has a knotted projection on the inner side; y3, which is of a lengthened and vaulted form, is supplied with 3 brushes, of which one short and thick and one longer and thinner sit at the point of the joint, the third is on the under side of the joint. The lowest joint of the inner branch is rather short, and the connection between it and the following one is oblique, compared to the longitudinal direction; i1 lacks brushes, i2 has 1, and i3 6.

The length of y3 is about as y1 + y2.

Especially characteristic of left foot is the joint y3 (fig. 22). Boeck says about it:

"Third joint of the outer branch is shorter than the second, and inwardly drawn out into a strong point, against which a curbed claw from the point of the joint can strike".

It is most likely that it is *h. norvegica* I have found, but in that case Boeck's description is not quite correct. On the joint y3 are 3 brushy projections. Of these the two short ones (s, t,) distinctly articulate with the joint, whereas the articulation between f and y3 is indistinct.

Fifth pair of feet in the male shows an astonishing likeness to the corresponding one in *h. abyssalis*, about whose appearance the excellent drawings of Giesbrecht give sufficient information (Monographie, Taf. 20, fig. 29, 30). However, the knotted projection on y2 of fifth right foot seems to be relatively smaller in *h. norvegica* than in *h. abyssalis*; the thin final brush is in *norvegica* shorter, forming about $^1/_3$ of the length of the joint (y3), while in *abyssalis* it is more than half the length of the joint. What chiefly seems to distinguish the two species is the appearance of y3 in left fifth foot, the brushy projection f in *norvegica* being distinctly projected from the joint, while in *abyssalis* they run together with no definite limits. Fifth pair of feet in the male further shows a distinct difference from the corresponding one in the Mediterranean forms.

It seems to me therefore undoubtful that the heterochæta found by me differs in species from the hitherto completely known and described forms of this genus. There is also reason to suppose that it is just this species on which Boeck has based his description.

What to me has been particularly decisive in the question of identity is Boeck's characteristic of the 5th pair of feet in the male. It is true that in my specimens the upper antenna are not shorter than the body, but this difference may depend on a wrong judgment by the describer.

From the south coast of Norway Möbius has mentioned a *heterochæta* that is identified with Brady's species *h. spinifrons* (1883). Giesbrecht, however, has proved that Brady's *spinifrons* is not the Mediterranean form (*h. spinifrons,* Claus), but rather *h. abyssalis*, Giesb. Möbius, however, mentions that in his specimens the first pair of antennæ were longer than the body, and as I have shown that this is actually the case in *h. norvegica,* it becomes likely that it is this species that Möbius mentions from Norway (Lindesnes).

Boeck states no definite finding place; as before mentioned, I took *h. norvegica* when gathering plancton, Feb. 25th, 1897, in the Ofotenfjord; depth 0—250 m. The place is situated not far from the telegraph station of Lødingen, which is in 68° 24′ N. 16° 1′ E. Grw. There occurred beside it, for instance *calanus hyperboreus* and *metridia longa.*

The hydrographical relations at the place where *heterochæta* occurred are as follows:

	Temp.	Saltness
0 m.	2.0 C.	33.54 ‰
120 -	2.8 -	33.73 „
150 -	6.0 -	34.65 „
250 -	6.1 -	34.96 „

The plancton was most abundant in the warm layer of 6° C. Most of *c. hyperboreus* and *metridia longa* was found there, and from this layer was probably also derived the *norvegica,* which in its occurrence rather presents itself as an arctic species, at any rate it is the first time that any *heterochæta* has been proved to occur as far north as the 68th degree of latitude.

Anomalocera pattersonii, Templeton.

During the North Ocean Expedition this species was observed in the Sognefjord and at 6 different stations in the south part of the North Ocean. I have taken it in the Herlö-fjord near Bergen, and at Solsvik just south of Bergen, where in August 1895 it occurred in great quantity.

The species of *acartia.*

Besides *a. longiremis,* I have, in plancton samples from the Pudde-fjord off Bergen, observed *a. clausii* and *a. discaudata*, Giesb. Of *a. clausii,* Giesb., I have also taken a single specimen, a female, at Röst (in Lofoten). I took the said specimen May 1. 1897 in plancton, 0—150 m. As far as I could judge, it showed a perfect agreement with the diagnose of Giesbrecht. On the rounded last thorax joint were several small points at the edge, and the two foremost abdominal segments had a row of points at the dorsal hinder edge. Length 1.5 mm.

Females of *a. discaudata* have such a characteristic appearance, that they cannot easily be mistaken for others. Some specimens were observed in the autumn 1896 in the Pudde-fjord at Bergen.

Oithona similis, Claus.

Syn.: O. pygmea, Boeck.

There is every reason to believe that Boeck's species *o. pygmea* is synonymous with *o. similis,* Claus. It is very common in the plancton off our coast, and Boeck says of the *pygmea,* that it is very numerous in the Kristiania-fjord in summer. The species is easily distinguished from the following one by the rostrum forming a right angle to the longitudinal direction of the body, so it cannot be seen from the dorsal side.

Oithona spinifrons, Boeck.

? Syn.: O. plumifera, Baird.

The other form of *oithona* is rarer than the former one. I have, however, seen it occured quite commonly in plancton samples taken just outside the Biological Station in November 1896. On closer examination it will perhaps be shown that the synonymy suggested above is correct. The antennæ are of about the same length as those of *o. plumifera,* but the projecting rostrum varies somewhat from the drawing of Giesbrecht in his well-known "Monographie". The length of the females I have found to be about 1.1 mm.

Microsetella atlantica, Brady & Rob.

From my plancton tables will be seen, that this species occurs in winter as well as in summer. During July and August 1896 it was very frequent in the fjords near Bergen, whereas it occurred rather sparely off the Biological Station in February 1897. Nor is it in Lofoten very frequent in winter.

Harpacticus chelifer, O. F. Müller.

Boeck has observed this species in the Kristiania-fjord and off the west coast of Norway. I have seen several specimens in a sample taken at the quay at the village of Sunderö in Vesteraalen. This copepod also occurred in the stomach contents of young green-cods that I caught at Røst in Lofoten. Otherwise the species goes still further north, having been for instance observed by Aurivillius in Kvænangen.

Idya furcata, Baird.

Boeck states that the species is common everywhere along the shore. I have seen it in plancton samples from the little fjord outside the Biological Station.

Conchoecia elegans, G. O. Sars.

(Oversigt af Norges marine Ostracoder, p. 117—118. Kristiania Viden. Selsk. Forh. 1865. The diagnose in Latin).

Ostracods have appeared in a few cases in the samples I have examined. Thus the above form occurred in a sample from 0—100 m., taken March 26th, 1896, 8 miles S. E. to E. of the fishing station Reine i Lofoten.

Conchoecia obtusata, G. O. Sars.

L. c., p. 118—119.

Of this species I found two specimens in a sample from about the same place (Mar. 23rd, 1896, 16 miles S. E. to E. off Reine, 0—130 m.).

Evadne nordmanni, Lovén.

At certain times the evadne is one of the commonest forms of the plancton. Thus in June 1897 the species occurred in great quantity outside the Biological Station.

Podon polyphemoides, Leuckart.

In the little fjord on which the Biological Station is situated, podon in 1897 occurred most frequently in the month of July. Podon, as well as evadne, are by G. O. Sars given among the species that serve as food to the sprat.

Parathemisto oblivia, Kröyer.

This arctic form I have observed at different places in the plancton, and also in the stomach contents of *gadus callarias* and *g. virens*. In stomachs of the latter species (Sunderö in Vesteraalen, Feb. 1897) I also took the forms far more rare on the coasts of Norway, of *euthemisto compressa*, Goës, and *euthemisto bispinosa*, Boeck.

Amathilla homari, Fabr.

(*A. sabini*, Leach).

Fry and young individuals of this amphipod occurred in the surface at Sunderö in Vesteraalen, Feb. 10th, 1897. Sars states that the species occurs in comparatively shallow water among algæ from Kristiania-fjord to Vadsö. Among other amphipods observed in the plancton may be mentioned *monoculodes tessellatus*, Schneider, taken in the Tromsö sound (April 20th, 1897) in a surface sample.

Boreophausia inermis, Kröyer.

This schizopod, which was sometimes found in great quantity in the stomach of the Lofoten cod, also appeared in the plancton samples. In the Östnes-fjord, Lofoten, also *thysanoëssa neglecta*, Kröyer, was found, whereas I have not yet obtained *nyctiphanes norvegica* in the plancton net, but have seen this species in great numbers in the stomach of *gadus virens*. Besides the three ephausidæ mentioned, the following belong to our fauna:

Euphausia pellucida, Dana.
Boreophausia raschii, M. Sars.
Thysanoëssa longicaudata, Kröyer.

Pseudocuma cercaria, v. Beneden.

Of this cumacé, which must probably be noted as a southern form, I took, in a plancton catch on Feb. 22th, 1897, a single specimen, in the harbour of Brettesnes, Lofoten. Along the northern coasts the species is likely to be rare. Schneider states that he has taken a specimen at Hillesö in Malangen-fjord.

In some of the plancton samples that I have examined, I have been struck by the number of foraminifera that occurred. The only explanation seems to be that a great deal of bottom forms are whirled up by the current and are kept floating for some time. Mr. Hans Klær of Kristiania has shown me the kindness of defining the foraminifera in some of the samples taken during my journey in 1897, and the result is here given from his manuscript:

March 11th, 1897. 5½ miles SSE of Ure in Lofoten.

Planorbulina lobatula, Walk & Jacob,	a few	specimens
Cassidulina crassa, d'Orb.,	—	—
Haplophragmium nanum, Brady,	one small	—

March 5th, 1897. S. to W. off Vater-fjord, 0—100 (Östnes-fjord).

Nonionina scapha, Ficht & Moll..	one defective	specimen
Planorbulina lobatula, Walk & Jacob,	some	—
Uvigerina angulosa, Will.,	a few	—
Pulvinulina punctulata, d'Orb.,	—	—
Cassidulina laevigata, d'Orb.,	—	—
Verneuilina polystropha, v. Reuss,	—	—

April 20th, 1897. Tromsö-sound, plancton from surface.

Polystomella striatopunctata, Park & Jones, 2 specimens.

March 11th, 1897, Gimsö-strömmen, plancton 0—50 m.

Planorbulina lobatula, Walk & Jacob,	some	specimens
— refulgens, d'Orb.,	—	—
— akneriana, d'Orb.,	one	—
Miliolina seminulum, Lin.,	—	—

Feb. 9th, 1897. Sunderö, Vesteraalen, in plancton taken from the beach.

Planorbulina lobatula, Walk & Jacob, one specimen.

April 30th, 1897. Röst. Plancton taken in the surface at the quay of Glea.

Planorbulina refulgens, d'Orb.,	many	specimens
— lobatula, Walk & Jacob,	—	—
— coronata, Park & Jones,	one	—
— akneriana, d'Orb.,	two	—
Uvigerina angulosa, Will.,	some	—
Cassidulina laevigata, d'Orb.,	—	—
Globigerina bulloides, d'Orb.,	—	—
Operculina ammonoides, Gronov,	one	—
Polystommella striatopunctata, Park & Jones,	two	—
Uvigerina pygmaea, d'Orb.,	—	—
Bullimina marginata, d'Orb.,	one	—
Haplophragmium canariense, d'Orb.,	—	—
— glomeratum, Brady,	—	—
Miliolina seminulum, Lin.,	—	—
Nonionina depressula, Walk & Jacob,	two	—
— stelligera, d'Orb.,	—	—
Textularia williamsoni, Goës,	some	—
Pulvinulina concentrica, Park & Jones,	—	—

March, 5th, 1897. Östnes-fjord, Lofoten. Plancton from 0—60 m.

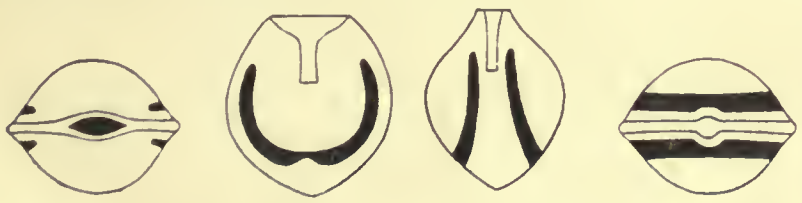
Planorbulina lobatula, Walk & Jacob,	many	specimens
— refulgens, d'Orb.,	—	—
— akneriana, d'Orb.,	two	—
Operculina ammonoides, Gronow,	—	—
Discorbina globularis, d'Orb.,	one	—
Cassidulina laevigata, d'Orb.,	some	—
Nonionina depressula, Walk & Jacob,	two	—
Miliolina semigumum, Lin.,	one	—

April 28th, 1897, 0 m., Röst.

Planorbulina lobatula, Walk & Jacob,	many	specimens
— refulgens, d'Orb.,	—	—
— coronata, Park & Jones,	two	—
— akneriana, d'Orb.,	some	—
Uvigerina pygmaea, d'Orb.,	—	—
— angulosa, Will.,	—	—
Polymorphina compressa, d'Orb.,	one	—
Cassidulina lævigata, d'Orb.,	some	—
Globigerina bulloides, d'Orb.,	—	—
Nonionina depressula, Walk & Jacob,	—	—
Haplophragmium nanum, Brady,	two	—
Pulvinulina concentrica, Park & Jones,	one	—
Discorbina obtusa, d'Orb..	—	—
Lagena lucida, Will. var. nordgaardi, n. v.	two	—

Description of the new var.

Pyriformis aut ovalis, vix compressa, obtuse marginata, utrinque costa lata prædita, entosolcrnica, apertura ovalis magna. Long. 0.33 mm.



This nice form is pear-shaped or oval, and scarcely compressed from the sides, the keel is obtuse and has on either side a parallel-running, thickened stripe, which ends above in a rounded point at a distance of about one third of the length of the shell from the mouth-opening; below it is somewhat bent upwards and somewhat narrowed by the button-shaped thickening that the shell ends in. This stripe is by transparent light dark, by surface light it is white, the elevation of it being quite small. At the mouth the shell is squarely cut off, at the lower end it is drawn out into an obtuse prolongation. The species reminds one very much of *l. quadricostata*, Reuss, but is distinguished from the latter species by the form of the stripes, the almost ball-shaped shell, and by the oblong aperture, which is pointed to both sides.

Two specimens were found by Mr. O. Nordgaard at Röst in Lofoten, and were called after him".

At the present stage of my investigations of animal plancton at our coasts, it is impossible to give any general description. What has till now been done in this field must rather be said to be of a reconnoitering kind. I have tried to obtain knowledge of the forms, their horizontal and vertical distribution, but have till now undertaken no quantitative plancton determinations. Of course, I have seen that there is great difference in the quantity of animal plancton in the months of September and February, for instance. In Lofoten it is rather poor in the latter month, especially in the surface strata, as is also the case in the fjords near Bergen. Both animal and vegetable plancton, however, is found also in the month of February. Arctic copepods, as *metridia longa, euchæta norvegica;* and *calanus hyperboreus,* I have scarcely ever taken in the surface strata (0—50 m.). But in the deep, where the temperature has been about 6° C., and the saltness 34—35 ‰, *m. longa* and *c. hyperboreus* have occurred in greater numbers, especially in Lofoten. Near Bergen too, I have observed a few specimens of the above-mentioned arctic copepods. Recently there occurred further a female of *heterochæta norvegica* (By-fjord, Aug. 24th, 1897, 0—300 m.). The occurrence of arctic copepods in our waters can scarcely be used to support the so called "current hypothesis". It is likely that dr. Hjort is right in saying that these animals occur in the deep of the fjords because arctic conditions are prevailing there.

Through a seal-hunter at Tromso I have obtained some plancton samples from the sea between Norway and Spitsbergen, taken in the summer season. In some of these occur great numbers of *calanus hyperboreus* from the surface strata. At our coast, however, I have, as mentioned above, hitherto only taken this species in somewhat deeper water. What appears particularly characteristic of arctic conditions, is the great uniformity throughout the year of temperature and saltness, and it is therefore likely that the arctic animal forms occurring in our waters keep in the deep, because the physical conditions there are most corresponding to those of the Arctic Ocean.

I thus think I have observed, in the case of several arctic copepods, that in our waters they are chiefly bound to the deep, and this circumstance may be one of the conditions that cause their

inferiority in number, size, &c. On account of the importance of light to the vegetable plancton world, the quantity of food, in summer at any rate, will be greatest in the surface strata; consequently a certain species will here find the best conditions of life, if the stay there is not rendered impossible by the physical conditions. In this connection I should also mention that for instance *calanus hyperboreus* from the surface of the sea at Jan Mayn had very red coloured antennæ, while those of specimens from Bergen and Lofoten were colourless.

The arctic copepods, *c. hyperboreus, metridia longa, euchæta norvegica, heterochæta norvegica,* seem to occur at our coast throughout the year, and their occurrence need not at all be dependent on transportation by arctic currents. When, on the contrary, such animals as *clio borealis* and *limacina helicina,* on rare occasions occur in our waters (according to statements by Boeck and Sars), it seems to me to support the opinion that some times arctic currents force their way up to our coasts.

I have mentioned above that the winter plancton is rather poor. There may, however, even in the month of February in Lofoten occur rather many forms. As an instance of this, I give a list of the contents of the samples from Liland (Ofoten-fjord) and Tjeldsundet. The diatomaceæ, dinoflagellata, tintinnodea, &c. have been determined by Mr. Jørgensen of Bergen.

	Liland, Febr. 24th 1897. 0—300 m.	Tjeldsundet, Febr. 24th 1897. 0—200 m.
Copepoda.		
Calanus finmarchicus, Gunn.	c	c
— hyperboreus, Krøyer	+	+
Metridia longa, Lubb.		r
Euchæta norvegica, Boeck	r	r
Oithona similis, Claus	c	
Microsetella atlantica, Brady & Rob.	c	+
Larvæ of copepods	r	
Chætognatha	r	
Diatomaceæ.		
Chætoceros boreale, Bail.	rr	rr
— criophilum, Castr.	rr	
— decipiens, Cl.	r	rr
— diadema, (Ehrb.) Gran	r	
Coscinodiscus radiatus. Ehrb.	r	r
— oculus iridis, Ehrb.		rr
— concinnus, W. Sm.	r	r
Striatella unipunctata, Ag.		r
Skeletonema costatum, (Grev.) Cl.	rr	
Campylodiscus Thuretii, Bréb.	rr	
Navicula latissima, Greg		r
Thalassiothrix longissima, Cl.	r	
Dinoflagellata.		
Ceratium tripos, (O. F. Müll.) Nitzsch.	+	+
v. bucephalus. Cl.	+	+
v. macroceros, (Ehrb.) Clap. et Lachm.	r	r
v. arcticus, (Ehrb.) Clap. et Lachm.	+	c
C. fusus, (Ehrb.) Duj.	r	r
C. furca, (Ehrb.) Duj.	r	r
Peridinium divergens, Ehrb.	+	+
— pellucidum, (Bergh) Schütt.	+	r
Gonyaulax spinifera, (Clap. et Lachm.) Dies.	r	r
Dinophysis norvegica, Clap. et Lachm.		r
— acuta, Ehrb.	r	r
Tintinnodea.		
Amphorella subulata, (Ehrb.) Dad.	rr	
Tintinnopsis nitida, Brandt	r	r
— beroidea, Stein		rr
Cyttarocylis denticulata, (Clap et Lachm.) Fol.	r	r
v. edentata, (Brandt)		rr
v. rotundata n. v.		r
Ptychocylis urnula, (Clap. et Lachm.) Brandt	r	
Radiolaria.		
Challengeria tridens, Hck.	r	r
Acantharia, sp.	+	+
Eucecryphalus, sp.	rr	
Chlorophyceæ.		
Halosphæra viridis, Schmitz	+	+

The signs above, as well as in the tables, have the following signification:

rr very rare
r rare
+ rather common
c common
cc very common

After the above was in the hands of the printer, I had an opportunity of seeing the great work of dr. Vanhöffen on "Die Fauna und Flora Grønlands"*). I see there that Vanhöffen in Karajak-fjord has found the male of *calanus hyperboreus* as well as the male (one specimen) of *heterochæta norvegica.* The total length of the latter was 3.57 mm., it was consequently a little bigger than my specimen. Vanhöffen also emphasizes the likeness with *h. abyssalis,* Giesb. I am, however, inclined to suppose them to be two different species, and I also suppose that the identity of the *h. spinifrons* described by Brady and *h. norvegica,* cannot be maintained with certainty.

*) Grönlands-Expedition der Gesellschaft für Erdkunde zu Berlin, 1891—1893, unter Leitung von Erich von Drygalski.

D. Final Remarks.

Professor G. O. Sars has, in my opinion, given the scientific statement of the fundamental causes of the great Norwegian fisheries. The biological investigations with which Mr. Sars introduced the practical scientific work, must be said to have given promises of great results that were to come. It is, however, a matter-of-course that a long series of special investigations still remain to be made. It will have appeared from what has been previously said, that both public authorities and private men have had their attention drawn to the difficult problem of the causal relation between the migrations of the fishes and the changing physical condition of the sea. Especially a great number of temperature measurements have been undertaken. The material of observations brought forward in the course of the years is rather considerable. We can now have a general idea of the distribution of temperature in normal years, and the measurements have also given us some notions about the swinging limits when the conditions take an unusual turn.

Professor O. Petterson has drawn attention to certain aperiodical changes of temperature in the Gulf Stream, supposing these to influence the regulation of the climate of Scandinavia*). In a later work the same author has put the irregularities of Scandinavian winter fisheries in connection with the greater or smaller volume of the Gulf Stream in winter. This is certainly a grand idea, and if it should prove to be correct, it will at once also be made possible to form an approximate opinion of the predestination of each year's fisheries, which would of course be of great economic importance.

It is unfortunately true that we are at present rather far from being able to "prophesy" the course of the Lofoten fisheries; for, to my knowledge, there has not yet been proved any direct connection between the variations in the physical condition of the sea and the fluctuations in the cod fisheries. The very circumstance that our herring fisheries show greater irregularities than the cod fisheries, points at the cod being more capable than the herring of withstanding negatively acting causes. It consequently becomes more difficult to determine the result of the effects on the cod fisheries than on the herring fisheries.

*) "Om möiligheten af väderleksförutsägelser för längre tid".

So much, however, seems to be certain, that the great conflux of cod and herring to the coasts cannot be principally dependent on hydrographic conditions, but on instincts in the animals themselves. The physical conditions consequently can only act in a modifying way on the instinctive migrations. That however the effects are strong enough to decide in many cases the fate of the herring fisheries, has been proved by the excellent Swedish investigators.

On the other hand, the attempt to explain the irregularities in the Lofoten fisheries by hydrographic causes has not succeeded. It appears also that the migration of the cod to Lofoten occurs one year after another under quite uniform conditions, because temperature and saltness in the deeper layers undergo very small changes indeed. It is true that it cannot be denied to be possible that the migration up on the Lofoten banks themselves may be delayed in such years when there is a comparatively sharp limit between the water of 5—6 degrees and that of 3 degrees, and that in consequence the catches in January and February will be smaller than usually. But from what I have seen, I must conclude that in the months of March and April the arrival of the cod and the spawning will occur in spite of the lower degree of temperature, and that a good fishing will then take place. In the month of March they take in Lofoten 60—70 per cent of the total catch, which no doubt depends on the circumstance that March is the spawning month proper, when the migration in upon the banks becomes general.

We are thus led to the conclusion that a principal factor in the produce of the Lofoten fisheries is the number of the fish that migrate inwards, and as the migration from the ocean, according to the observations hitherto made, goes on in such a great depth, that the annual variations in the physical conditions are very insignificant, we are obliged to look for another explanation of the changes in the numbers of the immigration. I am apt to think that much can be derived from changes in the number of fish staying on the outer banks. In the same way in which we speak for instance of a bad grouse season, by which we mean that the number of grouse is small, we may certainly also speak of a bad

cod season. And that a considerable difference in the year's number of cod-individuals fit for propagation exercises a perceptible influence on the produce of the winter fisheries, must be considered most probable. A reduction of the number of the cods of the season that are fit for propagation, may of course in part be caused by unfavourable physical conditions during the fry stages, (in analogy with the unfavourable influence of severe frost on the young grouse), but at present not very much can be said about this matter.

— In the present work I have tried, with a good will and at the best of my ability, to draw reasonable conclusions from the observations of others as well as my own. In certain points my views differ from those of previous authors. It may be that I have concluded more than the observations allow of, or that I have even judged of facts in a wrong way. It is however my hope that the material of observations I have brought forward will prove useful for future investigations.

Explanation of the Plate.

H. n. = heterochæta norvegica.
C. h. = calanus hyperboreus.
C. f. = — finmarchicus.
M. h. = metridia hibernica.
y1, y2, y3 = joints of the outer branch of feet.
i1, i2, i3 = — „ — inner — „ —
b1, b2 = basal joints of feet and maxillipeds.

Fig. 1. H. n., proximal joints of anterior antenna, male.
„ 2. — y1, y2, foot of fifth pair, female..... $^{100}/_{1}$
„ 3. — foot of fifth pair, female..... $^{100}/_{1}$
„ 4. — maxilla, female..... $^{100}/_{1}$
„ 5. — cephalothorax and abdomen, male.
„ 6. — distal joints of anterior antenna, male.
„ 7. — maxilliped of 1st pair, female ..... $^{60}/_{1}$
„ 8. — foot of 2d pair, female ..... $^{60}/_{1}$
„ 9. — maxilliped of 2d pair, male ..... $^{60}/_{1}$
„ 10. — posterior antenna of female ..... $^{60}/_{1}$
„ 11. — abdomen of female.
„ 12. — foot of 3d pair, male..... $^{60}/_{1}$
„ 13. — foot of 5th pair, left side, male ..... $^{10}/_{1}$
„ 14. — maxilliped of 2d pair, female..... $^{100}/_{1}$
„ 15. C. f., foot of 5th pair, left side, male..... $^{100}/_{1}$
„ 16. — the dentition curve on the basal joint of the same..... $^{100}/_{1}$
„ 17. — foot of 5th pair, right side, male ..... $^{100}/_{1}$
„ 18. C. h., cephalothorax and abdomen, male, lateral view $^{17}/_{1}$
Fig. 19. H. n., y3, foot of 4th pair, female ..... $^{100}/_{1}$
„ 20. — foot of 5th pair, right side, male ....., $^{100}/_{1}$
„ 21. — mandible of female..... $^{60}/_{1}$
„ 22. — y3, foot of 5th pair, left side, male ..... $^{100}/_{1}$
„ 23. — the cutting edge of the mandible (mandibellade), female ..... $^{100}/_{1}$
„ 24. — the inner branch of posterior antenna, female $^{100}/_{1}$
„ 25. M. h., abdomen of female, dorsal view..... $^{60}/_{1}$
„ 26. — the last joint of cephalothorax, female, lateral view..... $^{100}/_{1}$
„ 27. C. f., the dentition curve on the basal joint of the foot of 5th pair, female..... $^{100}/_{1}$
„ 28. C. h., the dention on the basal joint of the foot of 5th pair, female ..... $^{60}/_{1}$
„ 29. — foot of 5th pair, right side, male ..... $^{60}/_{1}$
„ 30. — the dentition curve on the basal joint of the left foot of 5th pair, male ..... $^{60}/_{1}$
„ 31. — foot of 5th pair, left side, male..... $^{60}/_{1}$
„ 32. H. n., foot of 5th pair, right side, male ..... $^{100}/_{1}$

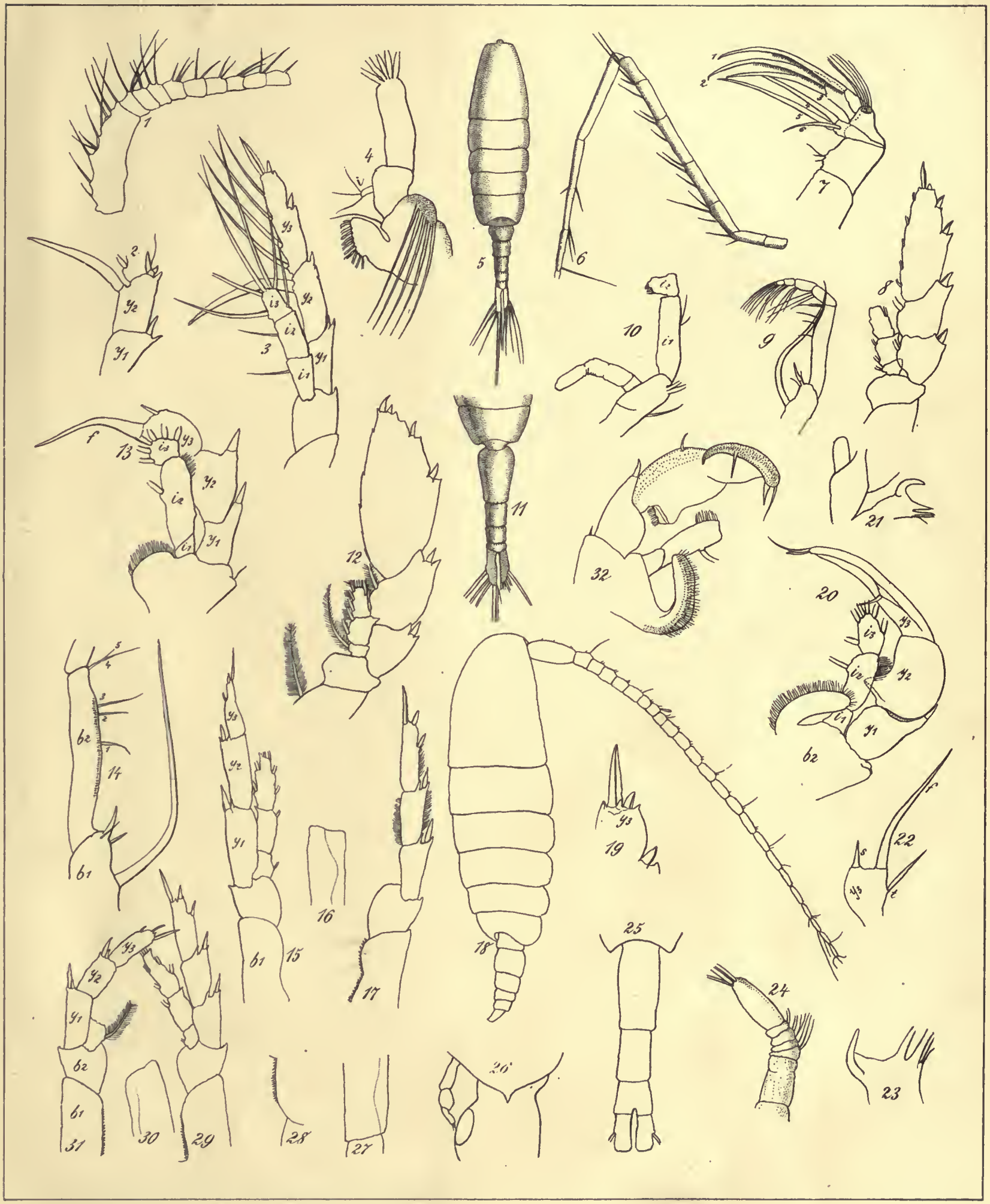
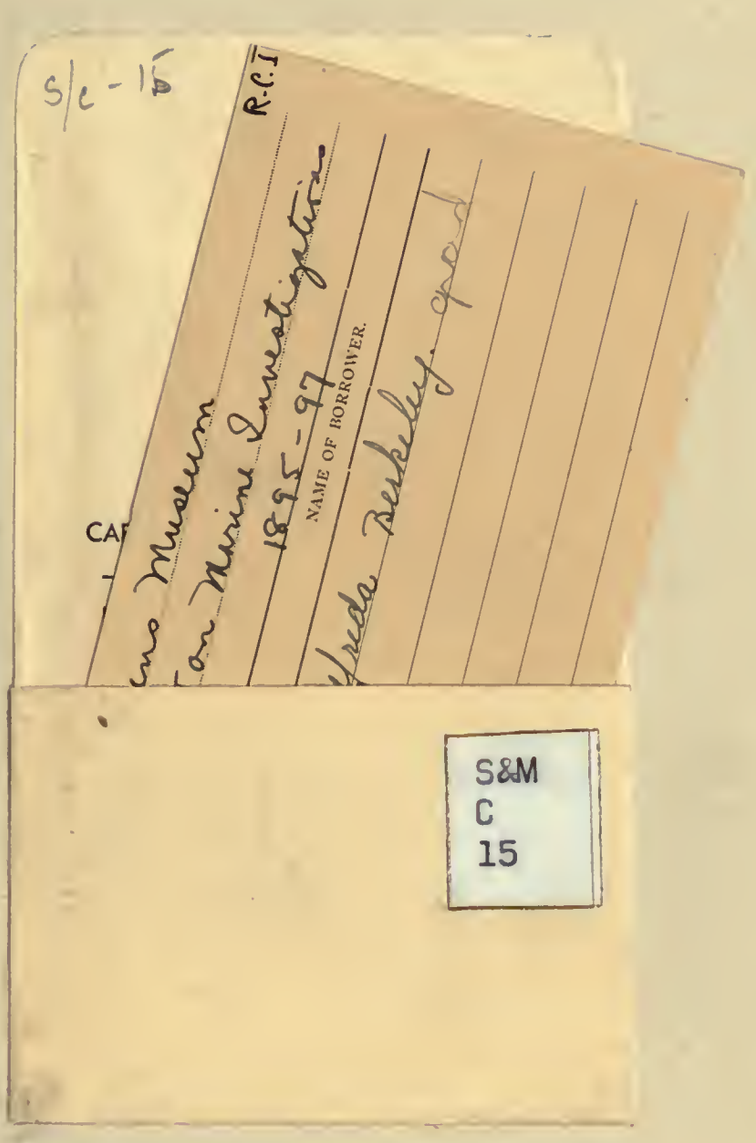
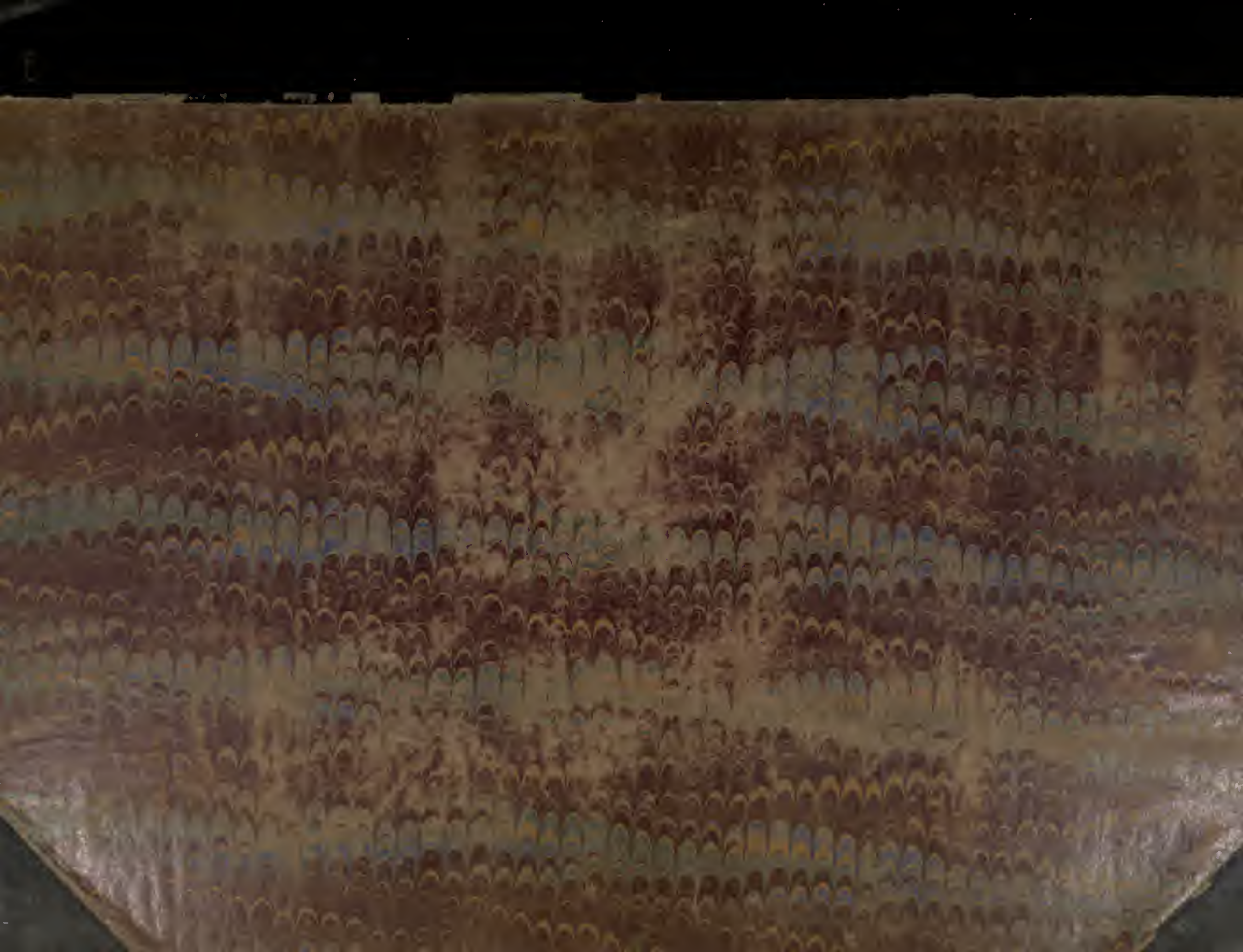


Fig. 1, 5, 6, 11 drawn by H. Bucher; the rest by O. Nordgaard.


S/C - 15
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